Cadent
Your Gas Network

# Appendix 09.02 Distribution Mains and Associated Services (Iron, PE, Steel & Other)

# Investment Decision Pack Overview

This Asset Health Engineering Justification Framework outlines the scope, costs and benefits for our proposals. We have prepared an enhanced Engineering Justification Paper (EJP) and a Cost-Benefit Analysis (CBA) for these assets.

**Overview**

Our customers want a safe and reliable service. We also have obligations under pipeline safety regulations (1996) which mean we must act where pipes are in an unsuitable condition to transport gas. The Health & Safety Executive (HSE) mandates certain mains replacement work through an enforcement policy that sets the standard for a safe service and reflects society's appetite for risk.

Our investments for RIIO-2 are driven by customers' expectations, an absolute duty on safety and works towards a hydrogen ready network at a sustainable pace. We have taken a whole network approach to developing the plan, coordinating programmes of work across repex and capex using a modelled approach which allows us maximise costs efficiency.

This paper covers investment in four areas:

1. **Mandatory iron mains replacement programme (the IMRRP)**

We have developed our programme to meet HSE requirements using modelling software which builds on the NOMs approach. The model contains details of our assets and forecasts how they will perform through time allowing a variety of options to be considered. We have considered delivery risk and how to maximise benefits through the consideration of different rates of programme delivery, work phasing and variations in the mix of work, to balance benefits of improved service (interruptions, safety, environmental impact) through time.

2. **Safety-driven mains investment**

The IMRRP has been grounded in the view that no individual should be exposed to the risk of more than a 1-in-1,000,000 fatality as a result of being within 30m of our distribution assets. Our investment plan ensures we work towards this principle for all pipe materials and diameters, addressing safety deterioration in our asset base.

3. **Cost-beneficial mains renewable**

There are also occasions when it is beneficial to customers to replace mains, even when this is not required for safety reasons, to deliver reductions in leakage, reduce interruptions to service or reduce maintenance costs. We have used out models to identify good value integrated schemes.

4. **The replacement of services associated with mains replacement**

When we intervene to replace the main, we will also replace the associated service pipe where it is metallic. This intervention is cost-effective and reduces safety risk. We capture the cost and benefit of replacing service transfers and relays in our CBA modelling.

| Summary of preferred option | Volume | RIIO-2 expenditure | Project NPV |
|---|---|---|---|
| Iron mains replacement programme including ≤2” Steel | 7,938km | | |
| Safety driven mains investment | 337km | Redacted due to commercial sensitivity | |
| Cost-beneficial mains | 250km | | |
| Total | 8,525km | | |

**Material Changes Since October:** The MRPS coefficients have been revised in line with the latest industry update. This has increased the length of safety work in the December plan. Dynamic growth has been included in the IMRRP length.

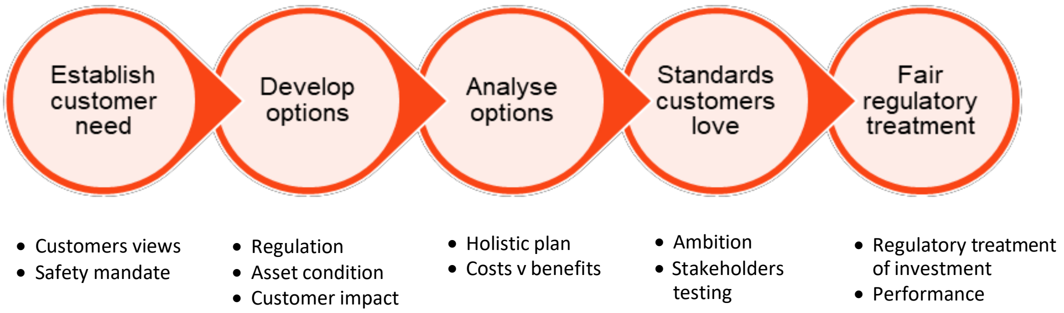
# Navigating This Document

Given the significance of this element of the submission and its importance to our customers and stakeholders, we have articulated the whole of the distribution mains renewal programme in this document. We have used the Ofgem's standard Engineering Justification template as a basis with additional sections to more fully capture our approach to customer engagement and decision making.

To avoid duplication for the reader, we have brought to the front of the document several sections of discussion. These include:

- **Section 3 'Introduction':** Overview of the investments covered in this document.
- **Section 4 'Equipment Summary':** The asset stock in scope of repex; further detailed breakdown of the asset stock is included in each subsequent section of the document.
- **Section 5 'Problem Statement':** Summary of the underpinning legislation and other drivers.
- **Section 6 'How we Have Built Our Plan':** An overview of the elements that construct our RIIO-2 mains renewal plan and how we have considered them together to drive efficiency.
- **Section 7 'How We Have Selected the Right Programme':** Commentary on how we have costed our plan and the work we have done to ensure the best value-for-money for customers.

We have followed five steps, shown in the diagram below, to move from a clear articulation of customer needs through options development and analysis to develop performance commitments that our customers love, and which give appropriate regulatory treatment. These steps are repeated for each area of investment. Ofgem's required elements are all covered.




In the table below, we have mapped the sections of the 'Mains Renewal Investment Methodology' document to the Ofgem 'Engineering Justification' document. The number in the table below maps the relevant section in this document to the Engineering Justification document title.

| | General | IMRRP Mains | Safety Mains | CBA Mains | Services |
|---|---|---|---|---|---|
| Introduction | 3 | 9.1 | 10.1 | 11.1 | 12.1 |
| Equipment Summary | 4 | 9.2 | 10.2 | 11.2 | 12.2 |
| Problem Statement | 5 | 9.3 | 10.3 | 11.3 | 12.3 |
| Probability of Failure | | 9.4 | 10.4 | 11.4 | 12.4 |
| Consequences of Failure | | 9.5 | 10.5 | 11.5 | 12.5 |
| Options Considered | | 9.6 | 10.6 | 11.6 | 12.6 |
| Business Case Outline and Discussion | | 9.7 | 10.7 | 11.7 | 12.7 |
| Preferred Option Scope and Project Plan | | 9.8 | 10.8 | 11.8 | 12.8 |

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# 2. Executive Summary

Our purpose is to keep the energy flowing; this is why we exist. We have a clear vision to set standards that all of our customers love and others aspire to. In order to achieve this, we have focused on delivering the outcomes that our customers tell us matter to them. Please refer to Section 5.2 Customer Insights for more information. For this investment area this is about delivering the basics to keep all our customers safe and warm. All that we have learned from our customers strongly supports this conclusion.

Safety, including the prevention of emergency situations that occur when our pipes leak, was consistently highlighted as the most important, or joint most important, priority across each engagement method during our research with over 23,000 customers, businesses and stakeholders. Engagement methods included deliberative workshops, a domestic customer survey, a public survey, focus groups with hard-to-reach groups, stakeholder interviews and vulnerability interviews. Ninety-four percent of respondents to our domestic survey said that the security of the network was very or quite important to them. During joint GDN engagement with stakeholders, organised by the ENA in 2018, investing in infrastructure to ensure asset integrity and safety emerged as strong themes. Participants who took part in acceptability and affordability testing stated that keeping gas flowing and ensuring customer safety was very important, and the main purpose of Cadent existing as a business.

Our proactive mains-replacement programme is one of the key ways in which we deliver a resilient network to keep the energy flowing safely and reliably. Responding to this customer demand by replacing aged metallic mains with new plastic pipes. While we complete this replacement work we also replace any associated metallic service pipes (pipes running from the mains to customer properties). Much of this work is mandated by the Health and Safety Executive (HSE) and, alongside this, we complete further work that delivers a positive benefit to all of our customers and wider society (cost-benefit driven mains). This investment is the largest in our plan: the rationale, options, and our proposed workload and investment levels are set out over the remainder of this document.

**A summary of our proposals**

Establish customer need

Our customers expect a safe and reliable service. The HSE mandates work through enforcement policy that sets the standard for a safe service and reflects the wider societal appetite for risk. The largest driver of work for us is the Iron Mains Programme (IMRP), which mandates the replacement of all iron pipes where they are within 30m of a building. This policy was established in 2002 and set a 30-year programme of work to remove all of these mains. The IMRP was refreshed into its current form, the Iron Mains Risk Reduction Program (IMRRP), at the start of RIIO-1. The IMRRP mandates the replacement of iron pipes up to and including 8” diameter (tier 1 pipes) but only mandates investment in pipes greater than 8”, up to and including 18” (tier 2 pipes), where these pipes are above a predetermined safety-risk threshold. Pipes above this threshold are deemed too present to much safety risk, and replacement is mandatory.

Alongside the IMRRP, we also have obligations under Pipeline Safety Regulations (PSR) which mean we must act where pipes are in an unsuitable material or condition to transport gas.

Beyond safety benefits, customers have been clear that they want us to reduce our environmental impact and improve reliability. Whilst replacement of pipes for safety reasons will deliver improvements in these areas as secondary benefits customers have also shown a preference for going further in improving these areas. In response we will look to deliver additional cost-benefit driven pipes that have a positive net present value (NPV) and incorporate a number of customer and societal benefits.

We are responding to customer needs via our mains replacement programme, which delivers significant benefits to our customers through improved safety, improved network performance, environmental benefits and resulting societal benefits.

This document covers the detailed investment case methodology for distribution mains renewal:

- mains replacement associated with the HSE mandatory IMRRP
- safety-driven mains investment outside the IMRRP (predominantly steel replacement)
- cost-beneficial mains renewal

This document also covers the service replacement associated with the mains replacement activities described above.

The plan has been developed using customer inputs combined with an advanced modelling approach which allows us to individually model all of the distribution mains assets we operate. The models allow us to forecast performance and costs into the future and assess the impact investment will have on the service we provide to our customers. Our approach allows efficiencies to be found in delivery by considering investment in single assets or in groups of connected assets. This allows us to consider trade-offs between benefit and cost to find the most efficient solution for all of our customers.

Develop Options

Our approach will move us towards 'all-plastic networks' which have the potential to unlock additional benefits from improved pressure management, readiness for future gases and redeployment of work teams. However, as there are still significant volumes of non-plastic pipe in our networks, we have rejected a policy of seeking to create all-plastic networks in RIIO-2. Such a policy would have seen us replacing greater pipe lengths and investing in pipes with lower NPVs, reducing customer benefits per £ invested. In developing this position, we have completed analysis to look at potential intervention plans for creating all-plastic networks. In this option we would be removing pipes which still had serviceable lives, that is, unnecessarily bringing replacement forward. We will revisit this approach for RIIO-3 once we are nearer to the tipping point of 'all-plastic' (i.e. when the % non-plastic in each network is reduced and less investment would be required to remove the final lengths) and our network has aged another five years.

In developing our plan, we have reviewed a number of investment options – considering both economic and service benefits – against customer preferences. Seeking to select a plan which represents the optimal mix of mandatory, safety and cost-benefit-driven work. We have tested our analysis with customers to further refine and improve our understanding of option benefits.

Analyse Options

In summary, our mains-renewal strategy can be seen in the table below:

<table>
<tr><th></th><th>LP</th><th>MP</th><th>IP</th></tr>
<tr><td>Iron Tier 1</td><td colspan="2">Iron Mains Replacement Programme</td><td></td></tr>
<tr><td>Iron Tier 2</td><td colspan="2" rowspan="2">Renew if above safety threshold<br>In-scope of CBA investment</td><td></td></tr>
<tr><td>Iron Tier 3</td><td></td></tr>
<tr><td>Steel Tier 1</td><td colspan="3" rowspan="3">Renew if above threshold and within a high-risk band<br>In-scope of CBA investment</td></tr>
<tr><td>Steel Tier 2</td></tr>
<tr><td>Steel Tier 3</td></tr>
<tr><td>Asbestos Tier 1</td><td rowspan="3">Renew if above safety threshold<br>In-scope of CBA investment</td><td></td><td></td></tr>
<tr><td>Asbestos Tier 2</td><td></td><td></td></tr>
<tr><td>Asbestos Tier 3</td><td></td><td></td></tr>
</table>

*Table 1: Summary of RIIO-2 Mains-Renewal Strategy (mandated work)*

*Note: grey boxes indicate there are no assets in this pressure material tier category. CBA can be applied to any asset.*

Our proposed RIIO-2 programme of work is comprised of 8,525 km of mains renewal and the replacement or transfer of associated services. Using the detailed costing model developed for RIIO-2, this will see us invest *XXXX* in our networks.

Our investments in RIIO-2 will deliver the following benefits:

- Reduce mains MRPS risk over RIIO-2 (from April 2019 base)
- Reduce mains failure, producing an opex saving for customers
- Reduce mains leakage, delivering environmental benefits and should reduce bills
- Reduce the probability of an interruption to supply
- Move towards a hydrogen ready network

Standards customers love

**This delivers a safer, more reliable, greener network which is cheaper to operate.**

Our proposed workloads for RIIO-2 are detailed in the following sections of this document:

- 7,785 km, HSE mandated mains replacement workload (the IMRRP).
- 153 km of ≤2" Steel associated with HSE mandated mains replacement
- 37 km, IMRRP mandated safety workload (tier 2a)
- 300 km mandated non-IMRRP safety workload
- 250 km, cost-benefit justified workload
- 318,622 service transfers & 538,400 service relays

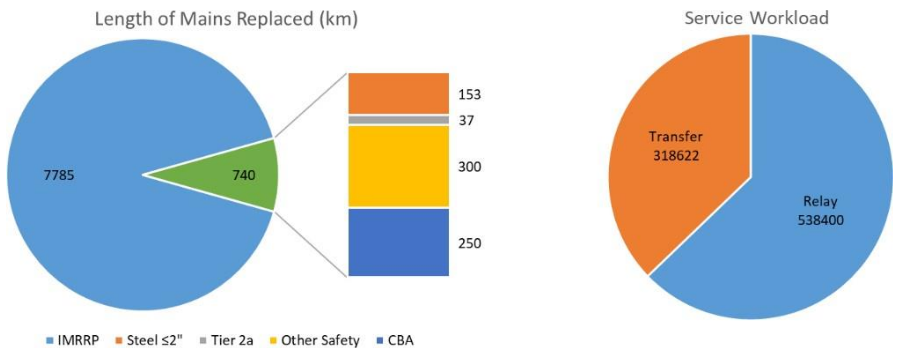


*Figure 1: Charts to illustrate km of mains renewal and service investment*

The delivery of these commitments will be regulated through a number of mechanisms, including performance reporting, price control deliverables (PCDs), uncertainty mechanisms and the Totex Incentive Mechanism (TIM). This represents a significant change from the regulatory funding of mains replacement in RIIO-1. During RIIO-1, mains replacement has been funded as a set ex-ante allowance for the delivery of the MRPS risk-removed score. This change in regulation will ensure that all networks are funded for the mix of work that they complete. We welcome this change as it supports our ambition to be trusted to act for our communities.

Fair regulatory treatment

The document that follows is structured around an investment methodology which ensures we are clear on the need and have considered the options available to us, analysed them and set out the deliverables that support our ambition – standards that all our customers love. Finally, we set out principles for fair regulatory treatment, ensuring the right balance of incentives and protection for customers.

# 3. Introduction

The following section sets out the investment case methodology for distribution mains and associated services.

A description of each area is shown in the following table.

| Title | Scope/Description |
|---|---|
| **Mains Replacement - Iron Mains Risk Reduction Program (IMRRP)** | Renewal of mains to achieve the HSE IMRRP, including ≤2” Steel |
| **Mains Replacement - Safety Threshold Work** | Renewal of mains driven by safety outside of the IMRRP |
| **Enhanced Maintenance** | Risk mitigation leakage surveys |
| **Mains Replacement - cost-benefit-driven work** | Cost-beneficial renewal activity |
| **Services – with mains replacement** | Replacement and transfer of services associated with mains replacement |

*Table 2: Investment areas detailed in this document*

Non-mains related service investments are excluded from this methodology document and covered in a separate engineering justification document (Appendix 09.03).

Investment for our London Medium Pressure scheme is excluded from this methodology document and covered in a separate engineering justification document (Appendix 09.06).

# 4. Equipment Summary

## 4.1. Distribution Mains

Our distribution mains form a network 126,000km in length, connecting our Local Transmission System (LTS) to the customer homes and businesses that draw gas from our network. They run underneath every street which has a gas supply.

The makeup of the networks is the result of over a century of investment, policy and regulation in the transportation of gas. Over time, there have been various approved materials to carry gas, sanctioned replacement techniques and maintenance regimes to manage the assets.

A summary of the asset stock for each region is shown in the table below. The network is split into diameter tiers:

- Tier 1: 8 inches and below
- Tier 2: above 8 inches and below 18 inches
- Tier 3: 18 inches and above

| Material | Tier | EoE (km) | Lon (km) | NW (km) | WM (km) |
|---|---|---|---|---|---|
| Iron | 1 | 7,502 | 4,072 | 5,205 | 4,140 |
| | 2 | 1,463 | 958 | 1,214 | 1,336 |
| | 3 | 319 | 575 | 439 | 220 |
| Steel | 1 | 1,966 | 634 | 982 | 1,034 |
| | 2 | 661 | 106 | 280 | 343 |
| | 3 | 383 | 238 | 152 | 123 |
| Polyethylene (PE) | 1 | 34,223 | 12,307 | 22,687 | 14,454 |
| | 2 | 2,752 | 1,324 | 2,118 | 1,657 |
| | 3 | 73 | 86 | 125 | 28 |
| Other (mainly Asbestos Cement) | 1 | 1 | 0 | 62 | 0 |
| | 2 | 0 | 0 | 4 | 0 |
| | 3 | 0 | 0 | 1 | 0 |
| **Total** | | **49,344** | **20,299** | **33,270** | **23,337** |

*Table 3: Asset Base as per 2018-19 RRP*

As of RRP 2019, the East of England and North West networks are the largest networks we operate in terms of length; however, they have the least amount of IMRRP work as a proportion of the network total asset base. Our North London network is the smallest that we operate; however, 20% of the assets are in scope of the IMRRP and will be renewed by the end of 2032.

East of England and the West Midlands have the highest portion of steel assets, at 6%, with North London at 5% and the North West at 4%.

East of England and the North West networks are 75% PE, with North London at 68% and the West Midlands at 69%.

## 4.2. Services

We have over 11 million service pipes supplying customers in domestic, industrial, commercial and multiple occupancy buildings (MOBs) direct from the network. The service pipe is the last part of the network connecting distribution mains to customers' meters, running from the public highway onto their property. Services volumes reflect the number of supply points in each network.

The following table shows the breakdown by network:

| '000s | EoE | Lon | NW | WM |
|---|---|---|---|---|
| Number of services | 4,024 | 2,275 | 2,693 | 1,965 |
| MOBs | 17 | 65 | 16 | 10 |
| Cadent Total | 4,041 | 2,340 | 2,709 | 1,975 |

*Table 4: Service Asset Base by Customer Type per RRP 2018-19*

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# 5. Problem Statement


The drivers of mains renewal are discussed below; these include safety, efficient network operation, environmental and wider societal needs. All these drivers provide benefit to customers. This section will:

- set out our relevant safety legislation and HSE guidance.
- summarise the customer research and customer needs – combining the 'hard financial values' with qualitative insight.
- describe our approach to Willingness to Pay (WTP) for interruptions and how this has been used.

## 5.1. Keeping You Safe

We have a duty to maintain a safe network, underpinned by several statutory instruments.

### Legislative Drivers

| Instruments | Main legislative drivers |
|---|---|
| **Pipeline Safety Regulations (PSR – 1996) (PSR13a – 2003)** | As a pipeline operator, we have duties under the Pipeline Safety Regulations (PSR 1996/ PSR13a 2003).<br>• Regulation 8 requires that our pipelines are constructed of a suitable material.<br>• Regulation 9 requires that our pipelines are constructed to be sound and fit for purpose.<br>• Regulation 13 requires networks to ensure that the pipelines they operate are maintained in an efficient state, in efficient working order and in good repair.<br>• These duties are absolute and there is strict liability.<br>• PSR 13a provides a defence to a breach of PSR duties but this is only for iron mains within the IMRRP (Appendix 5). |
| **Gas Safety (Management) Regulations 1996** | • As a gas transporter, we have duties under the Gas Safety (Management) Regulations 1996 (GSMR).<br>• To be able to convey gas in a network we must prepare a safety case that is accepted by the HSE as per Regulation 3.<br>• We must conform with that safety case as per Regulation 5.<br>• The duty to follow the arrangements in the safety case is only affected by the interests of health and safety and not any economic considerations. |
| **Health and Safety at Work Act 1974** | • As a company, we have general duties to conduct our undertakings in such a way as to ensure, so far as reasonably practicable, that persons other than themselves or their employees are not exposed to risks to their health and safety. |

*Table 5: Legislative Instruments*

In addition to the statutory instruments above, the RIIO-2 Price Control will see a continuation in the way in which we manage the iron mains replacement from RIIO-1 with the extension of the HSE Iron Mains Risk Reduction Program (IMRRP) Enforcement, referred to as the HSE Three Tier Framework. This Enforcement is driven by PSR, 1996.

The HSE's Three Tier Framework considers the following groups of iron pipes:

- Tier 1 - ≤8” diameter
- Tier 2 - >8” to <18” diameter
- Tier 3 - 18” and above

A summary of the enforcement approach is captured in the following table. Further details are given in Appendix 5 and are available on the HSE website.

| | |
|---|---|
| **Tier 1 Iron**<br>**≤8” diameter** | Pipes will be replaced on a pro-rata basis to ensure the replacement of all tier 1 pipes within 30 metres of a building by the end of 2032 |
| **Tier 2 Iron**<br>**>8” to <18” diameter** | Pipes will be remediated if they are above a risk threshold, with those below the threshold remaining in use, unless their risk increases to above the threshold.<br>A revenue driver is used in RIIO-1 to allow for uncertainty in this workstack. |
| **Tier 3 Iron**<br>**18” diameter and above** | Pipes will be subject to a maintenance regime approved by the HSE.<br>A threshold or revenue driver for this work does not exist in RIIO-1. |

*Table 6: Summary of three-tiers approach*

### 5.1.1. Engagement with the HSE

In addition to routine, ongoing discussions with the HSE as part of business-as-usual activity, the four Gas Distribution Networks (GDNs) have, to date, held five sessions with the HSE to specifically discuss the RIIO-2 process. From these discussions, we understand that the IMRRP will not be materially changed as we progress into RIIO-2 (i.e. there will be no repeat of the strategic review conducted prior to RIIO-1). There will, however, be a need to update the enforcement policy, and this will be a subject for ongoing discussion. Two material areas related to the IMRRP have been discussed:

- The continuation of the ‘SEED’ approach – this is discussed further below.
- The treatment of ‘stubs’ – it is assumed that this element of investment will not change, but greater clarity will be given in the enforcement policy (a change to this area would have a significant impact on our investment proposals).

Outside of the IMRRP, we have discussed the risk posed by steel. Building on the HSE/Ofgem research at the start of RIIO-1 (RR888 - HSE/Ofgem: 10-year review of the Iron Mains Replacement Programme) which highlighted steel as ‘an emerging issue’ we have discussed further research by the industry in this area. The industry is reporting increased failure from steel pipes. The HSE has encouraged companies to develop appropriate risk-based responses.

We have also held several bi-lateral meetings with the HSE, at a senior and tactical level, to discuss the specifics of Cadent's approach as outlined in this document.

## 5.2. Customer Insights

Customers have been at the heart of shaping our plans. Our overarching approach to customer engagement is presented in Chapter 5 of our Business Plan submission.

This section summarises key engagement areas relating specifically to our mains replacement programme (Appendix 7 gives specific details of our business options testing, which took place during summer 2019).

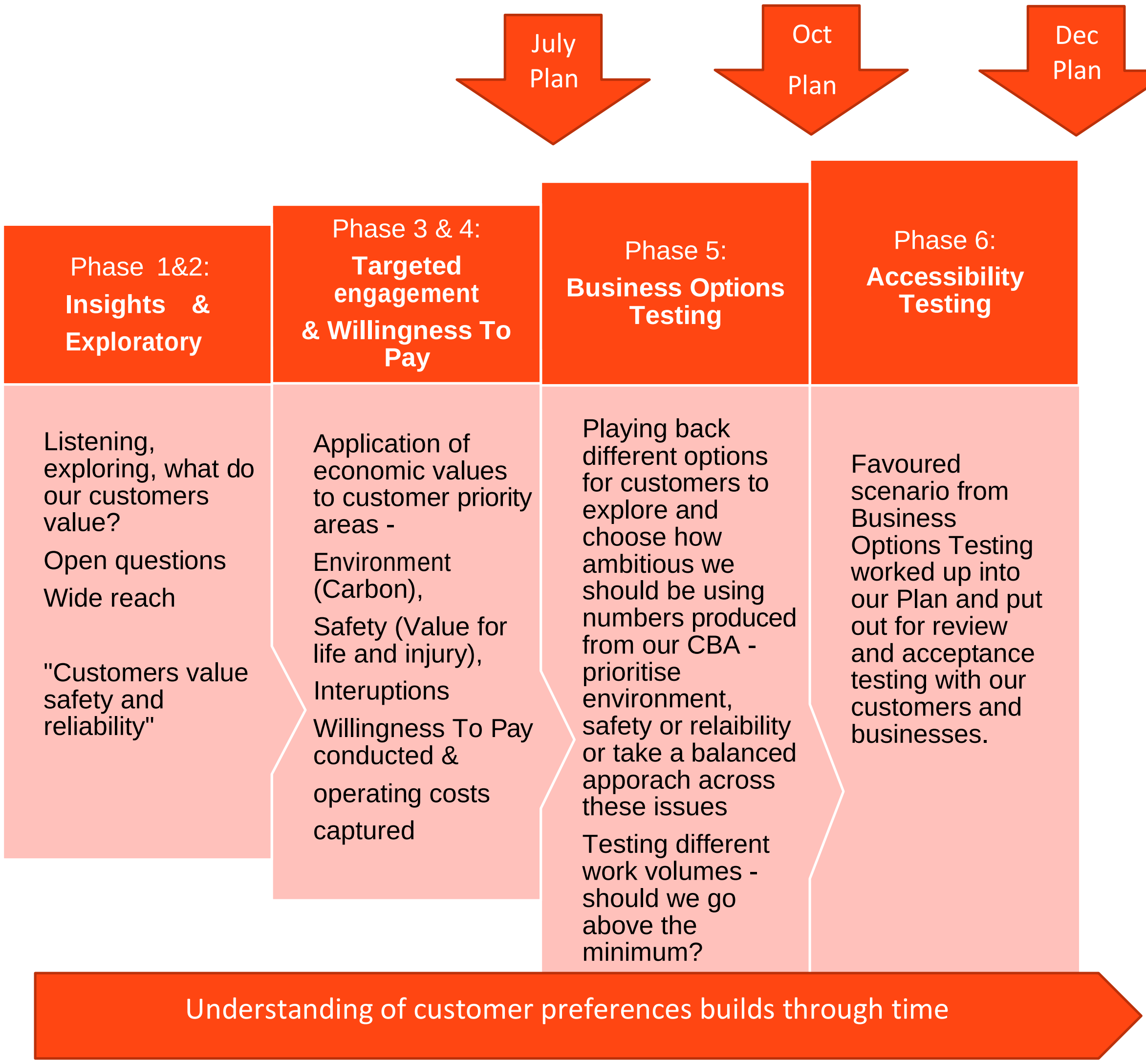



*Figure 2: Customer Engagement*

<u>Phase 1 and 2: Insights and Exploratory</u>

Safety, including the prevention of emergency situations as a result of leaks on our pipes, was consistently highlighted as the most important, or joint-most important, priority across each engagement method during research. This research included deliberative workshops, a domestic customer survey, a public survey, focus groups with hard-to-reach groups, stakeholder interviews, roadshows and vulnerability interviews.

- 94% of respondents to our domestic survey said that the security of the network was very or quite important to them.
- During joint GDN engagement with stakeholders, organised by the ENA in 2018, investing in infrastructure to ensure the integrity and safety of assets emerged as a strong theme.
- Ensuring a reliable supply of gas was also highlighted as a priority across our phase one and two engagement.

- 69% percent of respondents to our domestic customer survey said that guaranteed gas supply is very important to them.

Reliability was the joint second-highest priority in our public survey, after safety.

Other related feedback included:

- During focus groups with hard-to-reach groups, participants requested more proactive checking of pipes, such as regular safety checks and pressure monitoring, to predict problems before they occur.
- Most participants stressed that people in vulnerable situations and businesses that depend on gas should be protected at all times, and the disproportionate impact on customers in vulnerable situations was reinforced during vulnerability interviews.

Phase 3 and 4: Targeted Engagement and Willingness to Pay (WTP)

During phase 3, a targeted customer forum was held with over 100 customers across our networks participating on the topic of interruption and reinstatement. Research found that customers were primarily concerned with safety, especially when discussing unplanned interruptions and public reinstatement. Customers understood the safety precautions Cadent needs to take which could affect the amount of time off gas.

Through our WTP research conducted by Traverse/NERA we sought to estimate WTP to reduce the likelihood of interruptions. NERA used a mix of sources to develop the valuations, including stated preference research, revealed preference research and benefit transfer literature search. Other than the stated preference research, the WTP values produced are the same across all four regions. In contrast, the stated preference study provides valuations that differ slightly by regions.

Phase 5: Business Options Testing

Business Options Testing (BOT) provided the opportunity to test customer perceptions of Cadent's business plan options, quantifying and prioritising customers views. Where appropriate, assessment of the optionality within individual business commitments was included. Both quantitative and qualitative methods were used, including a consultation, surveys, workshops, forums and interviews. Using both methods enabled Cadent to gather in-depth customer views on the overall options set and how it met/or didn't meet customer's own views of 'what's needed' and how it addresses 'what matters to customers'. Over 6,000 customers and stakeholders took part in BOT, with a range of segments representing our network, including domestic customers, non-English speaking customers, customers in vulnerable situations, customers in fuel poverty, customers who live in multiple occupancy buildings, different size businesses and a variety of stakeholders.

Participants of business options testing were provided with options to replace different lengths of pipes, providing the benefits of each. 55% of survey participants want Cadent to replace more pipes than the legal minimum, to bring the benefits sooner. In the customer forum sessions, participants were asked to prioritise Cadent's pipe replacements (by safety, environmental impact, minimising disruption or a balanced approach) and discuss how they would want to pay for it (do cheaper work first or a flat profile). Overall, when replacing mains pipes, balancing the benefits and with smooth bills were the most popular options.

Further details are in Appendix 7.

Phase 6: Acceptability Testing

Plans have been subjected to a final round of testing ('acceptability and affordability research'). The purpose was to understand and measure customer and stakeholder reactions to our proposed commitments, understand to what extent our plan is acceptable and affordable, all informing the final version of our Business Plan. Testing was undertaken using quantitative and qualitative methods including surveys, workshops, forums and online communities to provide large volume sampling and build our understanding of customer views respectively. It was important that we gained views from both informed and uninformed customers and the research was structured to support this. Views were sought on both the overall plan and each of the outcome areas.

Over 5,300 customers and stakeholders took part, providing their views on the outcomes and priorities to deliver a resilient network to keep the energy flowing safely and reliably. Generally, participants were positive and liked the plan to deliver a resilient network. 83% of customers surveyed thought that the plans to deliver a resilient network were acceptable or very acceptable. 87% of survey participants stated that keeping gas flowing and ensuring customer safety was very important, and the main purpose of Cadent existing as a business.

### 5.2.1. Conclusion

Our customers expect us to keep them safe and we expect this of ourselves. Safety legislation and the HSE IMRRP provides a clear mandate on what we should be delivering to ensure the appropriate safety standards are maintained for our customers. Those pipes with the highest safety-risk scores are mandated for replacement in RIIO-2 through the above threshold mechanism. Other pipes are mandated for replacement in the period 2021-2032; allowing choices to be made on the phasing of activity – an opportunity to maximise customer benefits.

As such, safety-driven work must form the basis of any intervention plan on our network, by targeting our work effectively we can deliver enhanced customer benefits. We can also deliver greater benefits by undertaking work outside of that purely driven by safety.

This is the customer insight that has driven the development of our options and which has been tested with customers and stakeholders (particularly the HSE) as part of our approach to acceptability. The program will therefore meet the needs of our customers and stakeholders.

## 5.3. Efficient Networks and Wider Societal Benefits

The maintenance and operation of mains assets can be expensive when the assets reach the end of their serviceable life: costs of repeated repair can be high and disruption to customers significant. In addition, aged pipes have higher levels of background leakage, although the smaller leaks may not trigger safety driven replacements they do constitute a negative impact with regard to environmental harm – specifically greenhouse effects. We can put financial values on these elements to help us identify cost-beneficial pipes where the value of the repair cost, environmental impact or negative customer experience is greater than that which is acceptable.

This is an important element of the renewal programme as it allows the delivery of maximum value to our customers.

In our cost-benefit modelling approach for RIIO-2, we have factored in the cost of repair, the cost of lost gas, cost of carbon, the value of life, and customers' willingness to pay for interruptions.

| Customer Driver | Quantification (£ value) | Data source |
|---|---|---|
| **Environment – GHG emissions** | Increases from *XXXX* tCO2e in 2021 to *XXXX* tCO2e in 2071. | UK Government. Value agreed with Ofgem. |
| **Safety – Fatalities (£/fatality)** | Cost per Fatality *XXXX* | UK Government (HSE). Value agreed with Ofgem. |
| **Safety – Injuries (£/injury)** | Cost per Non-Fatal injury *XXXX* | UK Government (HSE). Value agreed with Ofgem. |
| **Leakage – commercial value of lost gas (£/m3)** | *XXXX* | Shippers. Value agreed with Ofgem. |
| **Cost of repairs (£)** | Ranges by diameter and network based on RIIO-1 data | Company accounts. |
| **Cost of replacement (£)** | Ranges by diameter and network based on RIIO-1 data | Company accounts. Benchmarked. |

*Table 7: Costs used in the CBA approach for mains*

### 5.3.1. Willingness to Pay for Interruptions Values

| Customer Driver | Quantification (£ value) | Data source |
|---|---|---|
| **Interruptions to supply – per property** | Range of values computed depending on duration and property type, e.g. *XXXX* per domestic property for up to 24 hours interruption. | WTP research. Independently assured. |

*Table 8: Willingness to Pay Results*

Nera's final recommendations provide a range (low to high) of Cadent wide valuations based on the triangulation of all data sources available. This included the values from the literature (e.g. Ofgem VOLL) which are consistent across the regions.

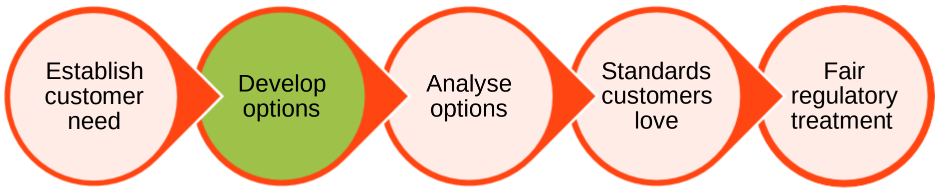
We have been conservative in using the proposed values in developing our plans and have tended to opt for the low end of the values from the estimated range. In part this was due to the use of the central and high values having a very significant impact on CBA results in early drafts of the plans – often producing results that seemed disproportionate.

### 5.3.2. Conclusion

We have clear valuations for these benefits, from trusted sources. We can therefore make a robust appraisal of options and identify good scenarios – those that maximise benefits – to be tested with customers. We are in a strong position because we have developed financial values for each of these drivers.

In addition to the drivers mentioned above, 83% of the UK's homes are currently heated by natural gas. However, the UK is legally committed to reducing carbon emissions, so the decarbonisation of heat is essential. A network with minimal ferrous pipes opens the possibilities for future gas options including different gas mixes or alternative gases such as Hydrogen. Despite not being valued in our cost-benefit approach, the IMRRP and additional safety and CBA-driven distribution mains renewal programmes contribute to building a future-ready network by ensuring that ageing ferrous mains are replaced by PE.

# 6. How We Have Built Our Plan




Our objective is to deliver a plan which best reflects customer and stakeholder expectations. To achieve this, we have developed a methodology which links asset performance to customer impacts, making use of models to evaluate options using CBA. This approach has several components, which will be described in this section. However, at its most fundamental level, our methodology has a transparent link between a pipe chosen for replacement and a customer benefit. The combination of these individual decisions is aggregated to produce cost/service options that can be tested with customers.

In developing the RIIO-2 plan, we have defined four distinct programmes of work, as detailed in the table below. Each of these programmes has a different investment driver and scope of investment.

| Title | Investment Driver Summary |
|---|---|
| **Mains Replacement - Iron Mains Risk Reduction Program (IMRRP) and associated ≤2" Steel** | • Mandated programme of works, entire programme to be delivered by the end of 2032<br>• Minimum renewal lengths determined by linear delivery of the programme as per HSE enforcement<br>• Inclusion of additional length to account for dynamic growth<br>• ≤2" steel based on RIIO-1 delivery rates |
| **Mains Replacement - Safety Threshold Work (Pipes Above Safety Threshold – PAST)** | • Mandated iron tier 2a renewal where assets breach safety threshold – Existing mechanism in RIIO-1<br>• Absolute duty to operate a safe network as per the PSR regulations for all other assets (i.e. extension of the RIIO-1 safety threshold principle to other assets) – New Cadent mechanism for RIIO-2<br>• The surveying of pipes that are above safety thresholds before they are renewed (safety risk mitigation), an extension of the RIIO-1 approach |
| **Mains Replacement - Enhanced Benefit** | • Renewal of assets at the end of their lives that provides a payback to the customer if renewed. Referred to as 'CBA pipes' in RIIO-1. |
| **Services – Associated with Mains Replacement** | • Output is driven by the mains-renewal activities detailed above |

*Table 9: RIIO-2 Programmes of Work for Mains and Services Associated with Mains Renewal*

While there are distinct programmes of work for mains renewal and the associated services, we have taken a single approach to developing the plan, considering each of the investment drivers in a unified way that allows the most efficient and coherent plan to be developed.

As a starting point, we have taken the fixed pipes above safety threshold (these are absolutely fixed and must be done in five years) and then used a modelling approach to find the most cost-beneficial way to populate the remainder of the programme, IMRRP (which must be delivered by 2032) and enhanced-benefit assets (CBA).

This approach ensures that all mains-renewal activity is considered in a single approach and that delivery efficiencies can be captured in our RIIO-2 costings and submission, producing greater customer benefits.

The diagram below shows the process we have been through to develop our repex plan.

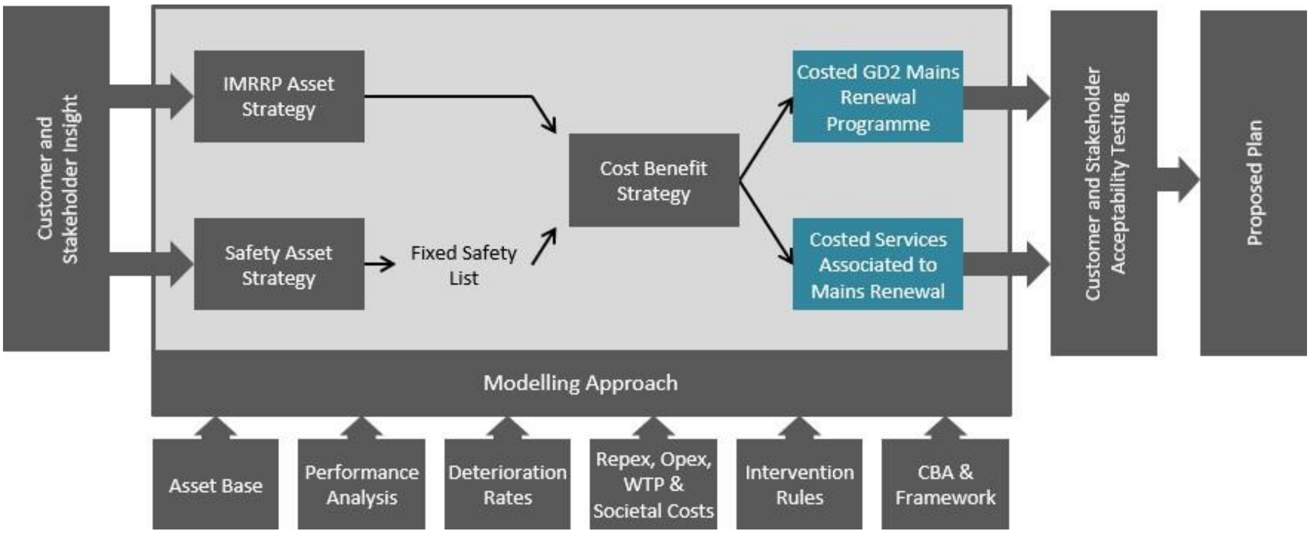
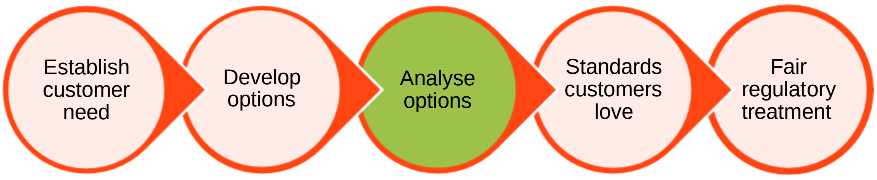



*Figure 3: Schematic of Modelling Approach to Develop the RIIO-2 Repex Plan*

# 7. How We Have Selected the Right Programme




The network output measures (NOMs) methodology[1] developed with Ofgem is an approach that allows us to understand risk on our assets and the benefit that investment will have. The reporting approach covers several asset categories including distribution mains. The distribution model is the most robust within the NOMs reporting suit.

In RIIO-1 we have invested in advanced software to allow us to build asset management capability using the NOMs/NARMs approach. We have included an optimisation capability which allows us to model different investment scenarios, produce optimised plans and test their cost-benefit.

The diagram below shows how the NARMs model has been enhanced to enable CBA to be carried out for the RIIO-2 plan and how the models are used to populate the various data templates Ofgem requires as part of the submission.

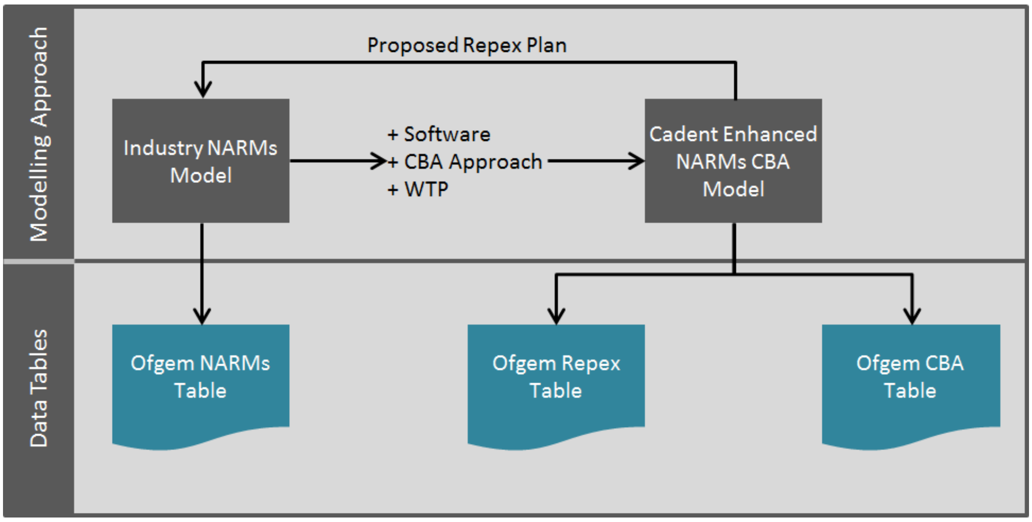



*Figure 4: Schematic Showing Model Development and Sources of Data for Data Tables*

[1] www.ofgem.gov.uk/system/files/docs/2017/09/noms_methodology_version_no._v3.2.pdf

The CBA capability within our software can find the solution to a problem with many restrictions and millions of viable, individual investment decisions.

The model contains a copy of the mains assets operated by Cadent and can forecast how the asset base will perform into the future in terms of asset failure, customer impact and cost. The model we have used for RIIO-2 planning is at an asset level, this allows each individual pipe and its performance to be modelled and results in a very precise output for the plan.

The model can be configured so that an optimised solution can be found for either a set of intervention constraints or a set of specific performance targets. For RIIO-2 planning, we have used the model with sets of intervention constraints (see the sections below).

Below are the central elements of the modelling approach we have used for RIIO-2 planning. They are essential in driving the investment choices and finding the most efficient plan for our customers.

**CBA Approach:** Cost-benefit analysis is widely recognised as an essential input into the business case for any investment proposal. The purpose of doing CBA is to assess the economic case for investment. It determines if the benefits of any given investment outweigh the costs. If they do, the investment is considered 'value for money'. Our formalised approach to CBA allows us to understand for each option costs in RIIO2 and beyond, NPV, payback, and the NPV/Spend ratio – which we consider and balance alongside stakeholder and customer views in assessing and developing our plans.

An important element of a CBA approach is the discounting of investments over time. Ofgem recommends the Spackman method for discounting. This method has been embedded in our modelling approach.

**Asset Failure and Deterioration:** To determine how assets perform a number of statistical models have been developed to predict the probability of failure given a set of asset attributes such as age, material, location, diameter, and length. These predictors generate a cohort approach which treats like pipes (same material/age/diameter etc) as equals.

The following failure types have been modelled:

- Corrosion
- Joint failure
- Fracture
- Interference
- Capacity

To allow the modelling approach to understand the differences between individual assets, we apply a tuner to the results of the final pipe level model. This model is applied to take into account all the variation that is not explained by the fixed predictors as well as any random variation between individual assets.

Model results are shown in the figure below. A perfect fit would lie along the diagonal dashed line, and it can be seen the effect of the Bayesian Tuner (green) is to significantly improve the model predictions at individual pipe level as compared to the un-tuned predictions (red). It should be noted that most of the data is clustered in the bottom left corners of each plot. We only apply the tuner to the last 3 years of failures so that the model reflects the assets as observed over recent history. This model is used for the starting positions in the model.

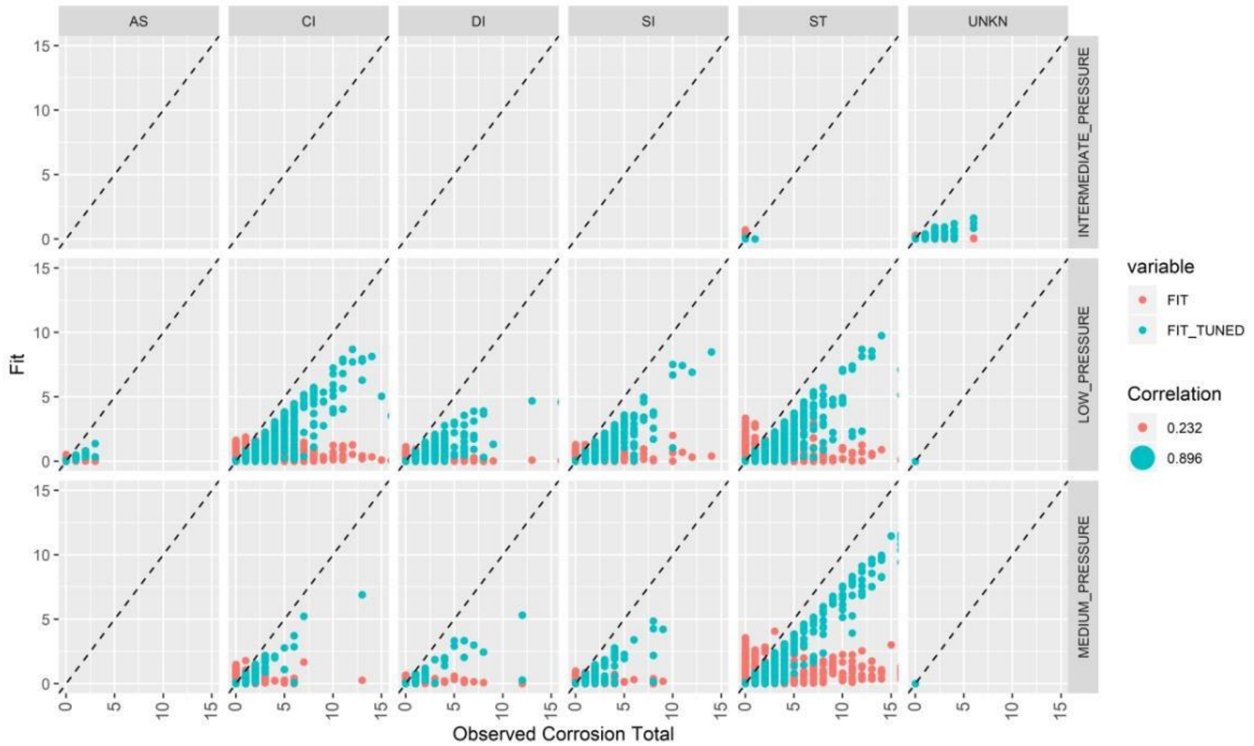



*Figure 5: Corrosion – pipe-level model – observed versus fitted/tuned.*

Deterioration is calculated by adding asset age into the existing failure model as a continuous predictor. Adding age into the model like this allows us to quantify the effect of asset age while normalising out all other pipe attributes. The end result is the quantifying of the percentage change in failure rates between pipes as age increases.

To further improve the detail on deterioration rates, two other models are run as before but with age interacted material and network separately. This means the model compares the impact of asset age for all pipes within a network or material. This gives a unique deterioration rate for each material and network. For corrosion, joint failure and fracture, 'material' was chosen as that has the biggest impact on pipe failure rates as assets age. For capacity and interference, 'network' was chosen as the way they change with age is more dependent on location than material.

| | Cast Iron | Ductile Iron | Spun Iron | Steel | Asbestos |
|---|---|---|---|---|---|
| Corrosion | 1.1% | 1.2% | 1.2% | 2.7% | 1.1% |
| Joint Failure | 1.3% | 0.4% | 1.7% | 0.1% | 0.8% |
| Fracture | 1.7% | 0.6% | 2.2% | 0.6% | 0.4% |

*Table 10: Deterioration Rate by Material.*

**Repex Unit Costs**: Our 2018/19 unit costs form the base of our plan. We have developed detailed cost models using our delivery experience over the start of the RIIO-1 period, considering the diameter, location, service density, insertion rate and length of scheme. Using these unit costs, the model can accurately assign unit costs to individual pipes within the network. For further detail see section 8.3.

**Super Strings**: Amongst various cost drivers, the repex unit cost is dependent on scheme length. So that the improved cost-benefit of longer length schemes can be captured and included within the RIIO-2 plan, the modelling approach we are using has the concept of 'super strings'. These are sections of connected pipes that are understood by the model, so it has the choice of either renewing individual sections of mains or grouping neighbouring mains into a longer scheme where it makes economic sense to do so.

The diagram below shows how the model understands the assets; the green shading indicates a CBA-positive asset and red a CBA-negative asset. The model can 'see' and invest in an individual asset or the same assets can be 'seen' as a continuous length. Investment in the longer length 'super string' may be more CBA-positive than investment in the three shorter individual cost beneficial sticks as there is efficiency in cost for delivering longer-length schemes (mobilisation and design costs per metre are reduced). The super string does not hide non-cost-beneficial work within a cost-beneficial scheme but rather understands that with reduced mobilisation costs an NPV positive scheme will become more NPV positive and an otherwise NPV-negative scheme will become less negative or in fact NPV-positive. For further discussion on the CBA approach see Appendix 4.

The superstring approach is both advanced and innovative; it brings some of the efficiencies that would previously be identified at the detailed design stage (or which might be missed altogether) forward to the beginning of the pipeline selection processes. This produces better schemes and reduces costs for customers. It also addresses feedback we have had from customers about dealing with issues on a single visit rather than leaving sections of pipe to be picked up later.

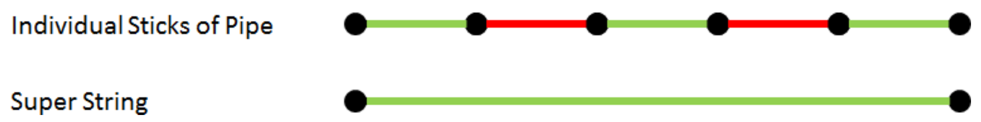



*Figure 6: Super String Example*

**Inclusion of Willingness to Pay (WTP)**: The Ofgem NARMs methodology does not include the valuation of customer WTP. We have collected WTP data on the frequency of interruptions to better inform the CBA calculation around this performance measure. This information has been built into our models. However, it has not been used as a basis for increasing work volumes but rather for improved targeting of investment and a more complete understanding of whole life benefits.

# 8. Mains Renewal Planning Assumptions


For the models to run, it is necessary to represent a number of ‘real-world issues’ as underpinning assumptions in the calculation. These assumptions are described below.

## 8.1. Total Length of Programme

To determine the overall length of the RIIO-2 mains workstack, consideration of the following activities is required:

- **Mandatory works:** The IMRRP addresses the failure of at-risk iron gas mains and the consequent risk of injuries, fatalities and damage to buildings. The delivery of this work is mandatory and must be completed by the end of the calendar year 2032.
- **Additional safety-driven workloads:** Pipes above safety threshold (PAST) workload are designed to ensure compliance with PSR by reducing the risk of injury, fatalities and damage to buildings.
- **Customer-driven:** Customer diversions are requested by customers and are therefore variable on an annual basis. This activity is mandatory (and may be funded by a third party). Although not part of the mains replacement programme, this work draws on the same workforce resource and must be considered as part of building a deliverable programme.
- **Cost-beneficial activity:** There are pipes on the network with a high failure rate or customer impact, or which are expensive to repair, that are cost-beneficial to renew. This work is not mandatory, but delivering it brings safety, environmental, societal and customer benefits.

In practice, the volume of the IMRRP and safety-driven work acts as a minimum collar on the workload Cadent can deliver over RIIO-2. The minimum IMRRP length would be 1,538km per annum on a flat profile.

The maximum cap on workload is driven by the volume of work available that is cost-beneficial, the resources available to deliver the workload and how much impact customers will accept on their bills. Although work may be calculated as cost-beneficial, customers may choose not to spend money on that activity – this relationship has been examined through options and acceptability testing with customers and is explored in the Enhanced Benefits section of this document (Section 11).

The Cadent RIIO-1 submission repex plan was to deliver, on average 1,850km of mains renewal per annum. Over the first five years of the RIIO-1 period, we have delivered on average 1,700km per annum. In 2019/20 we will have our peak delivery year, where we are expecting to deliver 2,100km of renewal.

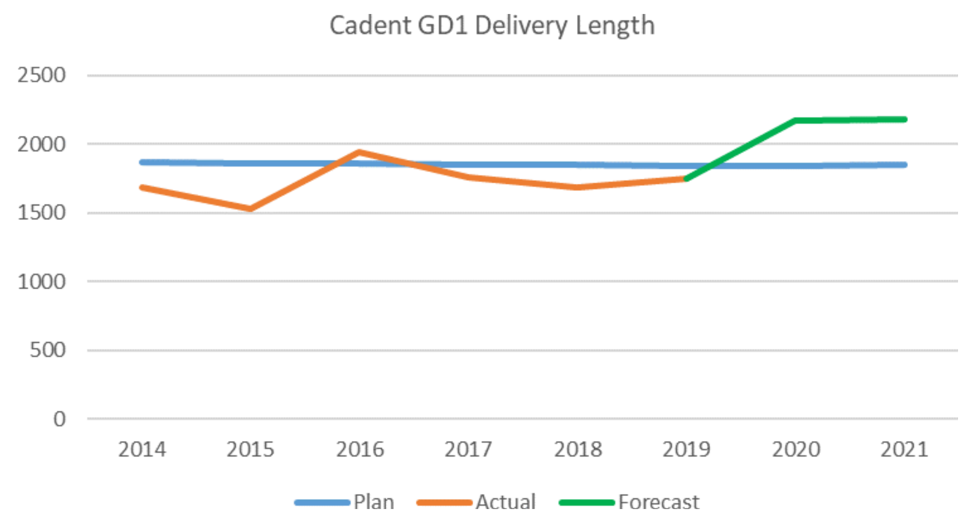



*Figure 7: Cadent RIIO-1 Repex Delivery Profile*

The overall length of the RIIO-2 plan will be dependent on delivering the mandatory and safety works to protect customers and then finding the right balance between benefit, deliverability and affordability for customers.

## 8.2. Changing Workload Characteristics

The characteristics of the workload, such as volume, diameter, location and type, are critical drivers of the costs within the programme. Our modelling approach will inform us on the workload mix and how this is changing over the RIIO-2 period. Where this will have an impact on the efficient level of costs, we have built these into our business plan. These are detailed in the following sections and will vary depending on the work type.

The key assumptions that we have in the plan are that all the IMRRP will be delivered by 2032 alongside any further safety work which must be delivered over the five years of RIIO-2. We will use the modelling approach to deliver this in a way which is most beneficial to customers.

The models take into account the characteristics of the assets that are being replaced. We have a high confidence in the characteristics of the assets as they are either inherent attributes of the asset themselves (e.g. diameter) or can be informed by reputable data sets, such as Ordnance Survey mapping data (e.g. surface type).

## 8.3. Robust and Efficient Unit Costs

The development of robust unit costs is a core part of the business planning process. We have extensive experience of mains replacement, **delivering over 7,000m of pipework every working day through RIIO-1**. We can therefore draw on a very large data set to develop robust unit costs.

Using the cost of delivery over the first five years of RIIO-1, we have developed our RIIO-2 unit costs. The results of the analysis show that the main drivers of renewal cost are:

- **Network:** each network has unique factors that influence cost.
- **Length:** there are efficiencies in delivering long, continuous lengths of renewal (mobilisation costs are spread out over a larger project).
- **Diameter:** larger-diameter assets cost more to replace.
- **Service density:** the more services there are to replace the greater the cost
- **Pipe location:** assets in carriageways cost more than those in footpaths or verges.

In addition to these attributes, there is a clear cost difference in the technique used to renew the pipe. Open-cut renewal, where the ground is excavated to expose the entire pipe, is generally more expensive than insertion, where the new pipe is pushed through the existing pipe.

To ensure that the most accurate representation of unit costs was captured, cost models (one for open cut and one for insertion) have been developed so that an individual pipe's characteristics can be used to predict the cost of its renewal. This allows the CBA model to consider each asset's benefits and costs individually.

To test the robustness of our unit-cost models, we have applied them to 'back cast' the expected RIIO-1 spend based on what we have delivered. The chart below shows the modelled cost and the actual cost of the work delivered in RIIO-1.

Redacted due to commercial sensitivity

*Figure 8: RIIO-1 Actual vs. RIIO-1 Modelled Unit Costs*

Both the insertion and open-cut predictions are a close match to the actual observed cost; there is a little more variability on the open-cut costs, but this is expected due to the smaller data set. Overall, this shows that there is a very good prediction of cost for both the open-cut and insertion models and that it is a robust basis on which to carry out RIIO-2 planning.

Because our unit costs for RIIO-2 planning are based on our RIIO-1 actuals from years one to five, any changes to unit costs in RIIO-2 will be a result of changes to the work mix and proportion of insertion.

## 8.4. Efficiencies

Our RIIO-2 forecasts, as well as adjusting for workload and work mix factors, also include ongoing efficiencies flowing from our transformation activities including from updating and renewing our contracting strategies. Our initiatives are outlined in Appendix 09.20 Resolving our benchmark performance gap. For repex activities, this seeks a 5% efficiency improvement by 2025/26 on the end-of-RIIO-1 cost efficiency level, delivering *XXXX* of efficiency over 5 years, to this investment area. All costs in this document are post efficiency.

## 8.5. Insertion Rates

Once we have established that a main is still required and needs replacing, we optimise the design, considering the use of no-dig techniques such as insertion. Whether we can insert a pipe or not is the most significant driver of total scheme costs and, on aggregate, the most significant driver of cost in our mains replacement programme. As described above, we have developed separate unit costs for insertion and open cut.

Insertion is generally the most efficient method of replacing mains. This technique, when compared to other options, dramatically reduces the amount of excavation work needed, which in turn reduces cost and disruption to the public. The method does, however, reduce the capacity of the network – the newly inserted pipe is smaller and therefore can transport less gas.

Wherever possible, we will design replacement projects that enable maximum insertion. However, it is not possible to achieve 100% insertion as it may be more economical to open cut mains in certain situations:

- Where capacity and security of supply must be maintained at or near existing levels and reducing the size would compromise customer service

- Where there are many connections and digging out each connection is more expensive than an open-cut replacement of the entire main (this is particularly relevant for steel pipelines which are more difficult to 'break into' than iron pipes are)
- If mains are in roads with service connections, where it may be more efficient to lay a new pipe in the footpath and abandon the existing main in the road
- For deep mains, where connections would require large and shuttered excavations
- For mains with numerous bends and fittings, such as valves and syphons, that must be excavated and removed to allow the insertion of the lengths in between

To enable us to have confidence in the insertion assumptions we have made for RIIO-2 and beyond, we have carried out several studies to test the options available:

- Reviewing pre-RIIO-1 delivery and the level of insertion achieved
- Designing networks using innovative semi-automated processes to maximise insertion
- Designing networks using a manual approach to validate the automated approach

**Proposed RIIO-2 Insertion Rates:** The analysis described above shows that there is a range in what the average insertion rate could be in RIIO-2. If we were to maintain current network pressures and carry out no reinforcement to increase insertion rates, a 76% average insertion rate would be achieved on tier 1 assets; these correlate to our pre-RIIO-1 rates.

With pressure increases and targeted network reinforcements (where it is cost-beneficial to do so), we can achieve higher average insertion rates. For RIIO-2, we have made the ambitious planning assumption that an average 86% insertion rate can be achieved on tier 1 mains, given pressure increases and strategic reinforcement, where it is cost-beneficial to do so.

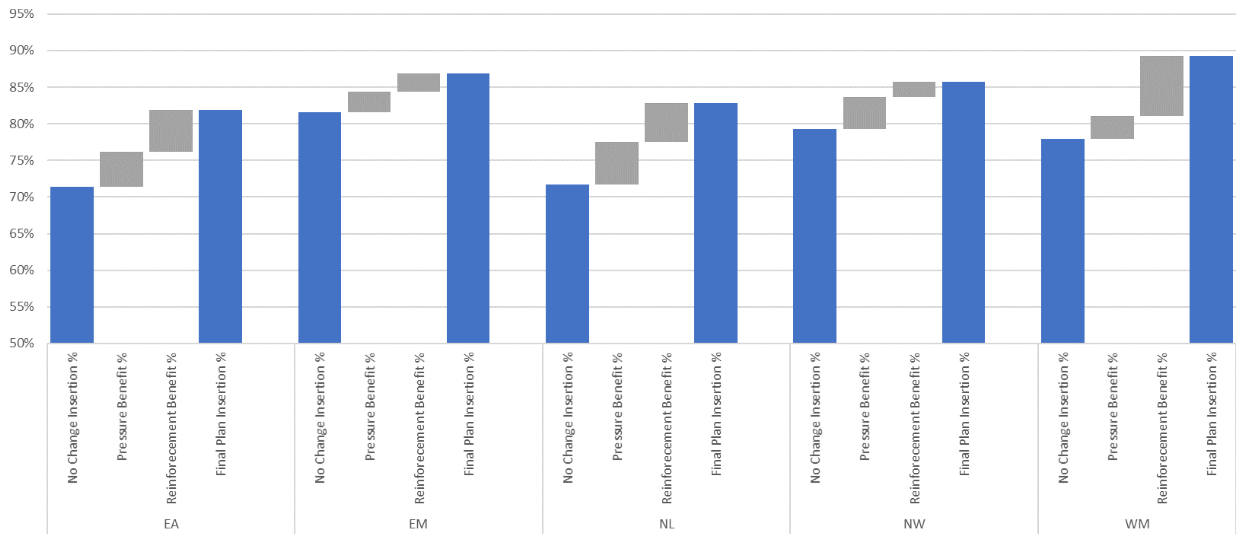



*Figure 9: Insertion Rate Analysis, Benefits of Pressure Increase and Reinforcement*

We do not consider insertion rates above 86% to be realistic as the level of pressure increases and the reinforcement required would be unsustainable and not cost-beneficial for customers (increasing reinforcement has diminishing returns in terms of mains replacement savings). Below is a table which shows the change to the submitted plan if we made different insertion assumptions by changing pressure and reinforcement proposals.

| Scenario | Insertion Rate | Reinforcement Investment Δ | Renewal Investment Δ | Net Change to Plan Δ |
|---|---|---|---|---|
| No Pressure or Reinforcement | 76% | | | |
| Pressure Increase Only | 81% | Redacted due to commercial sensitivity | | |
| Pressure & CBA Reinforcement (Plan) | 86% | | | |
| Pressure & Increased Reinforcement | 88% | | | |

*Table 11: Impact to Plan (RIIO-2) of Changing Reinforcement and Insertion*

The delivery of the 86% insertion rate will be challenging. However, it is in customers' interests as it equates to a saving of *XXXX* per annum compared to the 76% do nothing baseline.

**Pressure Impact:** In simple terms we would expect leakage to increase if pressure increases. However, it must be understood that under 'normal operating conditions' insertion does not result in the need to increase pressure. Normal conditions being defined in this case as an average year with an average winter. The pressure increase referenced in the text is only required in order to ensure that the inserted pipe will operate under peak (1 in 20) conditions. That is to say, in extreme winter conditions we would need to increase network pressure to maintain supplies once a pipe has been inserted into the network. As such, the increase in pressure and associated increase in leakage will only occur during rare events. This being the case, the negative environmental impact is not material and as such has not been included in the analysis.

To achieve an average insertion rate of 86% on tier 1 mains there will be challenges in maintaining our current pressure performance levels in cold winters. Although newly installed PE pipes will have lower leakage, increases in pressure will increase leaks from the remaining metallic mains in the area under high demand conditions. Without an inbuilt offset on future year baselines there is a potential to be impacted by the proposed leakage incentive mechanism as a result of variable weather. We will continue to work with Ofgem these mechanisms will work so that customers get the best overall outcome.

The evaluation of changes in environmental impact as a result of pressure change is outside the capabilities of the current model we have used to develop the mains plan. Similarly, we have not valued the reduction in carbon emissions of insertion techniques compared to open cut. If we were to factor in these changes insertion would still remain materially cheaper than open cut work and the optimal reinforcement rate would not materially change.

**Reinforcement Impact:** The volume of strategic reinforcement is informed by our analysis at an average of 9.7km per annum at a cost of *XXXX* per annum. We have profiled this work in the plan so that there is a greater delivery of this in the early years of RIIO-2 to enable a higher insertion throughout the period. This increase in spend is shown in the capital section of the BPDTs with the reduced repex costs shown in the repex table (the work is set out in Appendix 09.26).

**Regulatory Treatment:** We do not propose any special regulatory treatment for insertion rates for RIIO-2. If an uncertainty mechanism was introduced for insertion rate, then this could drive perverse behaviour such as a highly selective mains renewal programme to achieve the 'target' insertion rate. We are confident that the level of insertion we have proposed, based on detailed analysis and benchmarking against previous price control periods, will be sustainable over RIIO-2 and RIIO-3 and will provide a stable cost until the end of the IMRRP. Any variance in insertion rate and associated costs cost will be reported in RRP and subject to TIM.

**Summary of RIIO-2 Insertion Assumption:** An average 86% insertion rate has been assumed for tier 1 mains and the pre-RIIO-1 rates assumed for tier 2 and 3. Note that these rates can only be achieved with the associated mains reinforcement which is included in our capex case.

| Diameter Band | EA | EM | Lon | NW | WM |
|---|---|---|---|---|---|
| ≤75mm | 82% | 87% | 83% | 86% | 89% |
| >75mm to 125mm | 82% | 87% | 83% | 86% | 89% |
| >125mm to 180mm | 82% | 87% | 83% | 86% | 89% |
| >180mm to 200mm | 82% | 87% | 83% | 86% | 89% |
| >200mm to 250mm | 50% | 57% | 65% | 54% | 36% |
| >250mm to 355mm | 50% | 39% | 68% | 36% | 48% |
| >355mm to 500mm | 77% | 57% | 89% | 44% | 54% |
| >500mm to 630mm | 0% | 13% | 46% | 0% | 0% |
| >630mm | 0% | 0% | 4% | 0% | 0% |

*Table 12: Insertion Rates Assumed for Iron Mains*

**Steel Insertion Rates:** Insertion rates for steel tend to be lower due to the increased difficulty in cutting open the existing main. To forecast our future steel insertion rates, we sought guidance from our engineering delivery teams and sampled a selection of projects to provide an insertion rate.

In the table below, the differences between the renewal of an iron main and a steel main are detailed:

| Activity | Iron | Steel |
|---|---|---|
| Breaking into the Main | Iron is brittle and as such the main itself can easily be broken with impact techniques. This allows insertion location and service connections to happen quickly. | The main must be cut with special equipment: impact techniques do not work as the material is too ductile.<br><br>Every service connection must be cut using specialist equipment, resulting in longer replacement times, which impacts street-work costs. |
| Steel Specifications | N/A | MP Steel must have welded end points and transition points. This is a specialist technique which increases the cost. Welding increases the number of excavations to create additional space to work in. |
| Mains Condition | N/A | Planned and programmed projects will often grow as a 'good' piece of main is required to be found to complete the operation. This leads to the requirement to expose more main to complete a connection. |

*Table 13: Differences between Working on Steel and Iron*

For steel, we have used our experience in RIIO-1 and assumed an insertion rate of 50% for steel mains >3” for RIIO-2 and beyond. This level of insertion on steel mains is seen as challenging by our engineers and delivery partners given the difficulties we have listed above.

| Diameter | EA | EM | Lon | NW | WM |
|---|---|---|---|---|---|
| >3” | 50% | 50% | 50% | 50% | 50% |

*Table 14: Insertion Rates Assumed for Steel Mains*

## 8.6. Lay to Abandon Ratio

Mains workload within our business plan is defined as either ‘abandon’ or ‘lay’ length in kilometres (km).

- Abandon kilometres relate to the length and mix of mains that are being abandoned (or decommissioned) from the network.
- The lay workloads reflect the length and mix of mains laid (newly installed); this can be the same, more, or less than the lengths that have been abandoned.

Abandoning mains without having to lay a replacement pipe is the most cost-effective way of removing risk because, apart from the costs of cutting off and making the pipe safe, there are unlikely to be any other costs. We are essentially removing pipes from the network which, due to local changes in demand or network configuration, are no longer required. Where possible, we will abandon a pipe rather than replace it, reducing costs to customers.

The capability to ‘abandon only’ is primarily influenced by:

- The number of service connections on the pipe
- The network configuration

In RIIO-2, there will not be an increase in opportunities to ‘abandon only’, because the opportunities have been maximised in earlier control periods. We have assumed that the ‘lay to abandon’ ratios will be in line with those in RIIO-1.

| | EoE | Lon | NW | WM |
|---|---|---|---|---|
| Tier 1 | 1.001 | 1.015 | 0.993 | 0.994 |
| Tier 2 | 1 | 1 | 1 | 1 |
| Tier 3 | 1 | 1 | 1 | 1 |

*Table 15: Lay to Abandon Ratios Observed over RIIO-1*

The lay to abandon ratio is a low-sensitivity element of the costs model. This is because our unit costs are based on the RIIO-1 newly laid assets (as per RRP), and therefore the RIIO-1 downsizing assumptions are captured inherently in the unit costs.

## 8.7. Downsizing Assumptions

If a new pipe is to be installed, and can be installed by insertion, we need to understand how much smaller the inserted pipe will be. This leads to two scenarios:

- Within-diameter band downsizing – for example, 90mm insertion in 4” (101mm) pipe (both pipes are in the >75mm to 125mm diameter band).
- Downsize by one diameter band or more – for example, insertion of a 75mm (≤75mm diameter band) in 4” (>75mm to 125mm diameter band) pipe.

Typically, due to system capacity constraints, we will downsize by one band, although we will also downsize a small portion of pipes by more than one band (the majority of these will be large-diameter tier 2 and 3 pipes).

We have assumed that we will deliver a one-band reduction for assets that we insert. This is in line with the planning assumptions we are using in RIIO-1.

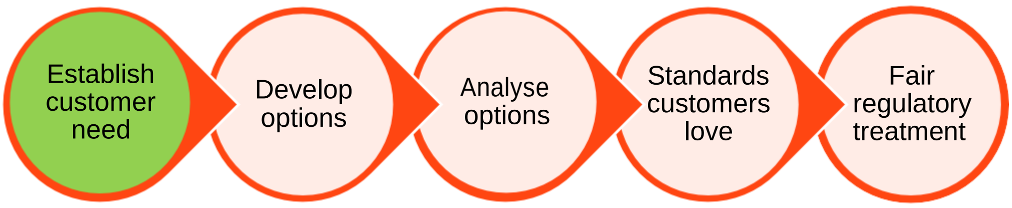
The downsizing assumption is a low-sensitivity element of the costs model. This is because our unit costs are based on the RIIO-1 newly laid assets (as per RRP), and therefore the RIIO-1 downsizing assumptions are captured inherently in the unit costs.

# 9. Investment Methodology – IMRRP

## 9.1. Introduction

The HSE's enforcement policy[2] for the IMRRP addresses the failure of 'at risk' iron gas mains (i.e. high-risk pipes within 30 metres of buildings) and the consequent risk of injuries, fatalities and damage to buildings. It is designed to secure public safety while allowing efficiency, environmental, strategic and customer-service factors to contribute to driving the programme.

The IMRRP is a mandatory programme of work to ensure the safety of our customers. The replacement of aged iron pipes with new PE will also deliver wider customer and societal benefits including reduced repairs (cost and disruption), reduced leakage and reduced interruptions to supply.




## 9.2. Equipment Summary

At the end of RIIO-1, there will be 16,945km of tier 1 iron mains within 30 metres of a building that are recorded in our MRPS, which is the industry-standard safety risk assessment tool. The table below shows the details of these assets (total kilometres)[3]:

| Ofgem Diameter Band | | East of England (km) | North London (km) | North West (km) | West Midlands (km) | Cadent (km) |
|---|---|---|---|---|---|---|
| Tier 1 | **≤3"** | 104 | 16 | 338 | 105 | 564 |
| | **4"-5"** | 3,900 | 1,977 | 2,478 | 1,858 | 10,213 |
| | **6"-7"** | 2,234 | 1,325 | 1,617 | 1,187 | 6,363 |
| | **8"** | 1,080 | 729 | 687 | 809 | 3,305 |
| **Total** | | **7,318** | **4,047** | **5,121** | **3,959** | **20,444** |
| **Remaining RIIO-1 workloads** | | 1,201 | 675 | 898 | 728 | 3,504 |
| **Remaining Tier 1 workloads post RIIO-1** | | **6,117** | **3,372** | **4,223** | **3,231** | **16,945** |

*Table 16: Asset Base for Assets in Scope of the IMRRP as per RRP 2018-19*

These assets have a safety risk score which is calculated by the MRPS. The risk score represents the number of incidents (property explosions) per annum we would expect from these assets.

[2] http://www.hse.gov.uk/gas/supply/mainsreplacement/index.htm. See also Appendix 5.

[3] The distribution of these pipes, by council boundary is shown in Appendix 9.

Due to investment in RIIO-1, the risk of these assets (as recorded in MRPS) is as low as it ever has been, by the end of RIIO-1 no asset will be above the ALARP threshold without a plan to replace it.

*Picture 1: Example of a Cast Iron Main*

## 9.3. Problem Statement

For RIIO-2, the HSE has confirmed that the risk posed by all tier 1 pipes still needs to be removed by the end of 2032 or sooner, as these pipes have historically presented the most significant risk of a Gas in Building (GIB) event, the precursor to an explosion. A ‘do nothing’ scenario has not been considered for the IMRRP as this would be a failure to meet our legislative requirements.

As described in Section 5 we have developed our tier-1 project selection with legislation, customers and network performance in mind. The way we select and deliver our IMRRP will impact several key outputs including mains risk, repair volumes, interruptions, leakage and customer experience.

Our objective is to deliver the IMRRP by 2032 in a way that provides the value customers want, is sustainable with regard to delivery and is stable until the end of the programme.

As part of routine mains renewal activity, we replace any connected steel mains which are ≤2” in diameter. This approach is embedded in our safety case (via REP/2) and cost-effectively removes safety risks. The benefit of this investment is an improvement in safety for customers and the avoidance of having to revisit the same location to replace these assets later.

### 9.3.1. Narrative Real-Life Example of Problem

The below example is a summary of an incident that happened in Shropshire in 2010 as investigated by the HSE[4], where an escape from a gas main caused an explosion, severely injuring six people. The incident was caused by a 9" main (this would is a Tier 2 pipe in the IMRRP); however, the impact of the gas escape is the same as could be caused by any asset of any diameter.

At approximately 11.30 am on Sunday 3 January 2010, an explosion and subsequent fire destroyed 1-5 Bridge Street, Shrewsbury, Shropshire. Six people suffered major injuries; several others suffered minor injuries. A number of properties in the area were also significantly damaged and Shrewsbury Town Centre was partially closed for several days causing disruption for local residents and businesses.

*Picture 2: The Shrewsbury Gas Explosion on Sunday, January 3, 2010*

All four occupants of 1-5 Bridge Street suffered major injuries when they were either thrown from the building or buried in the debris. The explosion damaged two sides of the property. Debris was thrown some distance from the building into the neighbouring Shrewsbury Hotel car park, damaging a number of vehicles, and the surrounding areas.

A family of six were near or within their car in the car park at the time of the explosion. Two of them suffered major injury from flying debris. Many of the neighbouring buildings suffered damage due to the debris; this was primarily damage to windows and facade areas rather than significant structural damage. The explosion damaged other utilities within the Bridge Street area (e.g. telecommunications infrastructure and traffic light systems).

The following key conclusions emerged from the investigation:

- Mains gas leaked from a fractured low-pressure cast iron gas main located in the footway immediately in front of 1-5 Bridge Street.
- The gas accumulated within 1-5 Bridge Street.
- The gas was ignited by a source within the building leading to the explosion.
- The particular ground conditions, including the corrosive nature of the soil and the stresses imposed by structures near to the main, may have contributed to the unpredicted failure of the main.

The HSE's investigation has concluded that National Grid Gas (now Cadent) had correctly applied their gas mains maintenance procedures in relation to the low-pressure main. The main had been appropriately risk assessed and was not subject to leakage reports, thus not identified for proactive replacement prior to the incident.

[4] http://www.hse.gov.uk/gas/supply/shrewsbury-explosion-report.pdf

### 9.3.2. Spend Boundaries

The spend detailed in this section is for the replacement of the mains assets in scope of the IMRRP.

## 9.4. Probability of Failure

The method by which a gas main fails largely depends on the material the asset is made from. Cast iron and spun iron pipes are prone to brittle failures and therefore their failure mode is to fracture either along the pipe length or circumferentially. Ductile iron is less brittle than cast and spun iron pipes are; therefore, fracture is less common. However, they do corrode in localised areas (1-2m sections) which can lead to gas escapes.

Failure of a gas main leads to the escape of gas. Once this is detected, either through leakage detection or being reported by a customer, a repair is affected (either a pipe clamp or short-length replacement).

Analysis of the number of repairs taken from core company systems shows that the number of failures on (all, including the small length >30m from a property) tier 1 iron mains is decreasing over time as the IMRP and IMRRP replaces tier 1 iron mains with PE. The number of failures shows some yearly variation: this is expected due to the impact of weather and other external effects.

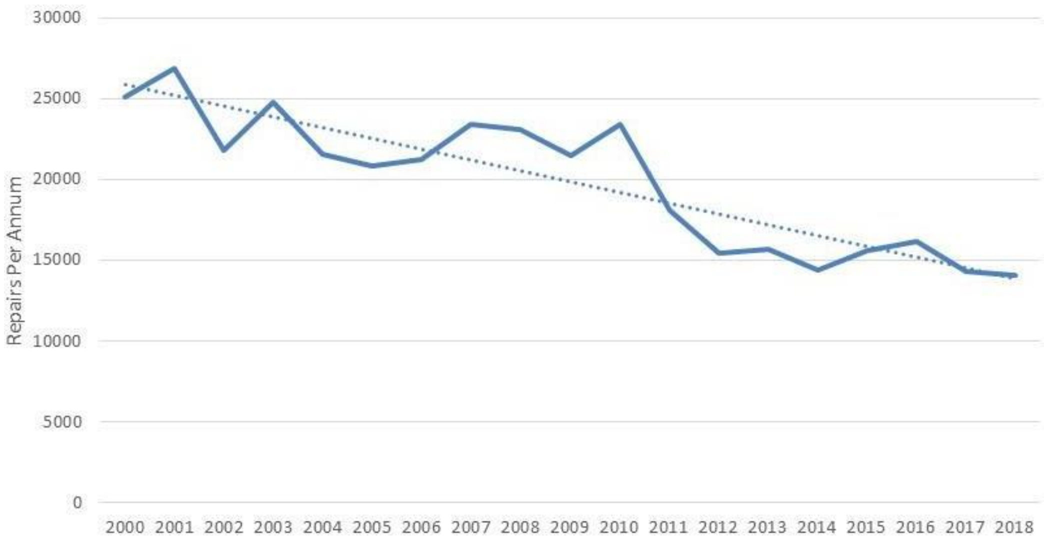



*Figure 10: Iron Main Gas Escapes Through Time*

There is a general downward trend in failures, however when this is normalised by pipe length it can be seen that there is a small underlying deterioration in the number of failures from tier 1 cast iron mains. This shows that the renewal carried out in RIIO-1 has not been enough to beat deterioration.

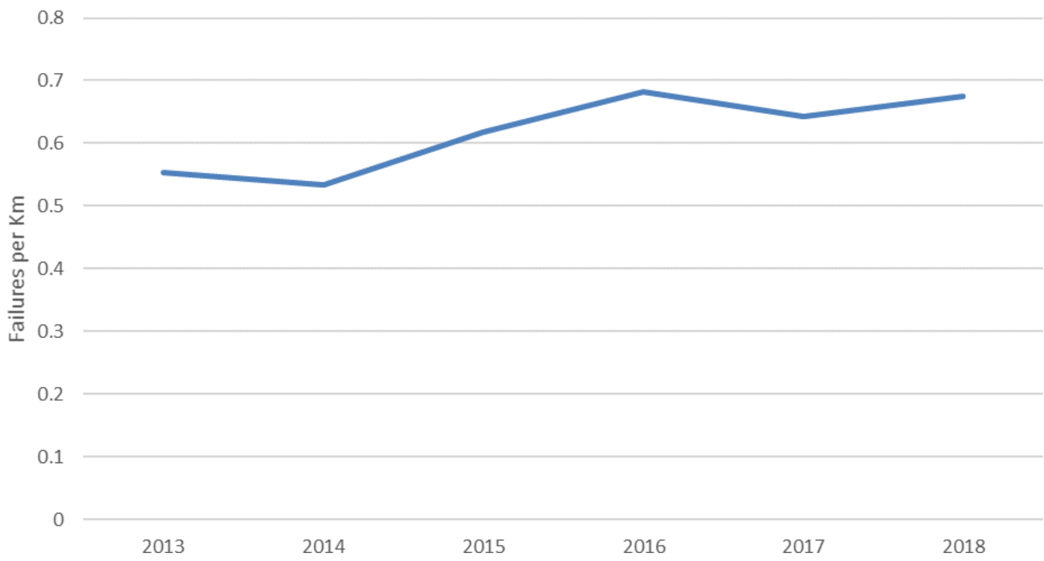



*Figure 11: Failure Rate Tier 1 Iron Mains*

As the total volume of failures is reducing it shows that the IMRRP is having the desired impact of reducing the risk to which the public is exposed. It also shows that there is an underlying deterioration in the asset base that needs to be addressed through the continuation of the IMRRP.

### 9.4.1 Probability of Failure Data Assurance

The IMRRP is a response to national failures (and high consequences) which have led to a targeted enforcement programme. We have a high confidence in our probability-of-failure analysis as this is based on a large data set collected over many years. Our approach to forecasting deterioration is detailed in Section 7.

## 9.5. Consequence of Failure

The aim of the IMRRP is ultimately to reduce the occurrence of fatalities and injuries (example detailed in Section 9.3.1) due to failed iron distribution mains. Explosions are caused by gas tracking into properties, which then builds up and ignites. GIB occurrences may result from any type of distribution main failure but have historically been more likely when a cast or spun iron main fractures, or a ductile iron or steel main has a corrosion hole.

The trend of mains incidents for the past 28 years is shown in the figure below. The number of incidents that occurred due to the failure of a distribution main each year is shown in blue. A five-year rolling average is shown in orange.

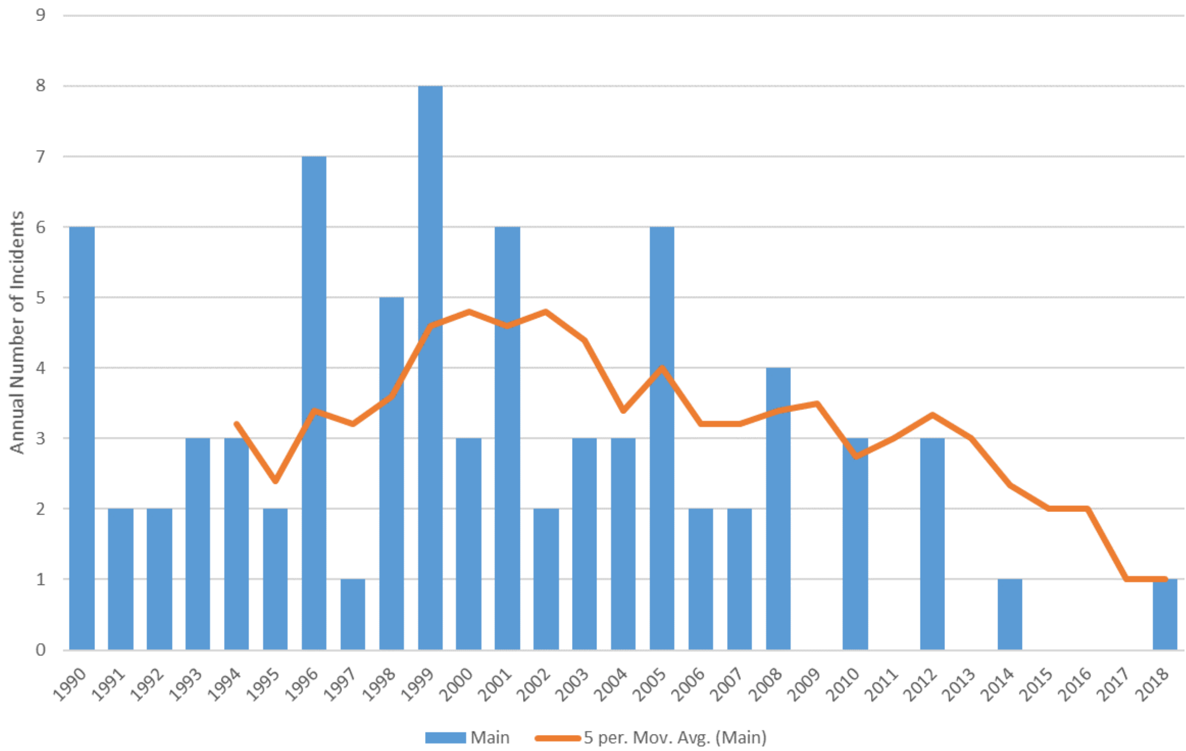
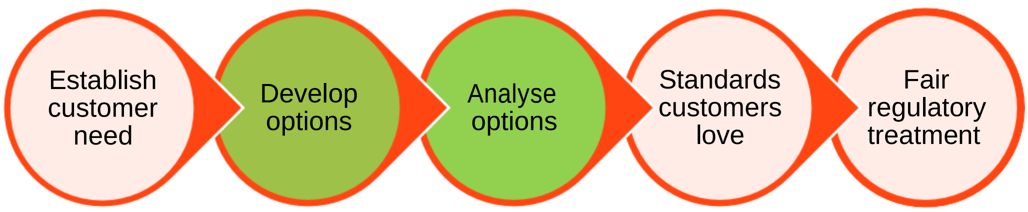



*Figure 12: Number of Incidents Caused by Mains Nationally*

The trend in the numbers of incidents occurring each year due to failure of a ferrous distribution main has significantly reduced. The number of incidents expected to occur each year is now below one. However, this is still too high as on average there is one fatality for every 2.2 incidents.

## 9.6. Options Considered




To keep our customers safe, the assets in the scope of the IMRRP programme must all be removed by the end of 2032, as detailed in the HSE enforcement. We have choices about the pace and order in which we renew these assets; this section will describe the development and analysis of the options we have considered in building the plan.

**Replacement Technique:** The HSE will consider an iron pipe to be decommissioned when it is no longer used to carry gas, where a PE or other pipe has been inserted into an iron pipe or, effectively, a new pipe has been constructed. If a spray-lining technology has been applied, using an existing pipe as a mould for a new pipe, the existing iron pipe will be considered decommissioned only when the internal pipe is itself capable of meeting the requirements of PSR Regulation 5 without any contribution from the external iron structure. We assume that there will be no spray lining work in RIIO-2 as the material science is not yet far enough progressed to meet the requirements of the HSE i.e. a fully structural spray liner.

**Phasing for safety (SEEDs):** At the start of RIIO-1, tier 1 IMRRP pipes were ranked based on their MRPS risk score and 20% of the agreed IMRRP length was allocated to the highest scoring pipes. These 'SEED' pipes were mandated for replacement between 2013 and 2021 by the HSE Enforcement Policy. The remaining 80% of the applicable population being selected using a range of drivers.

For RIIO-2 we considered three SEED options:

| Option | | Description |
|---|---|---|
| 1 | No SEEDs | The identified SEED pipes will be abandoned by the end of RIIO-1, other than a small proportion that will be deferred for future replacement in accordance with procedures agreed with HSE. As such, this element of the HSE enforcement policy will be delivered.<br><br>This will leave a population of pipes in RIIO-2, and beyond, that in RIIO-1 were not mandated for replacement at a set time within the programme.<br><br>This being the case the SEED approach would not carry forward into RIIO-2 as the identified risk has already been removed. |
| 2 | 5% SEEDs | Rank pipes based on their latest MRPS risk score, allocating 5% of the allowed length to create new SEEDs. The reduction in the volume of SEEDS would be on the basis that the RIIO-1 delivery of SEEDs and ALARPs will flatten the MRPS risk profile making SEED targeting less effective. |
| 3 | 20% SEEDs | Continuation of the approach we have taken in RIIO-1. Rank pipes based on their latest MRPS risk score, allocating 20% of the allowed length to create new SEEDs. |

*Table 17: SEED Options*

For RIIO-2, we have assumed that we will not use the concept of SEED pipes, as enforced by the HSE in RIIO-1. We have discussed this change with the HSE and shared the details of our pipe-by-pipe risk assessment with their analysts.

The universal SEED approach is no longer required if we have a method in place for effectively identifying, managing and replacing higher-risk pipes.

The iron pipe population still poses a material risk. However, 'The overall reduction and flattening of risk scores within the tier 1 pipe population' observed by the HSE at the start of RIIO-1 is now even more evident, with little variation between risk scores. Looking to 'slice' out and mandate a subset of 'highest risk' pipes in 2021 is unlikely to materially influence the total risk removed in the period. We have presented data to support this statement at our meetings with the HSE.

On this basis, and to promote regulatory simplification and transparency, we recommend that the concept of 20% mandatory SEEDs is removed from the HSE enforcement policy for the remainder of the IMRRP. Cadent will agree on its own safety case with the HSE to describe how it will continue to manage risk.

**Note that the 0% figure does not represent an agreed position with HSE and if the HSE requires a SEED element to the plan there may be delivery and cost implications. We would lose opportunities to produce the best 'super string schemes' and, as such, average scheme length would decrease and costs would rise.**

**ALARP**: In addition to SEED pipes, ALARP (As Low As is Reasonably Practicable) pipes were introduced for RIIO-1. This mechanism enforces an agreed minimum risk threshold which ensures no individual should be exposed to a risk of more than the ‘broadly acceptable risk’ of 1 in 1,000,000 fatalities as a result of being within 30m of our distribution assets. For RIIO-2, we will enhance this approach by introducing a pipe and societal threshold, this is further discussed in the Safety Threshold Appendix 2.

No additional lengths or costs are included in the plan for IMRRP ALARP activities. It is assumed that the reactive length of ALARP will be small and the funds to renew ALARP pipes will come from the IMRRP allowance. This is the approach that has been used in RIIO-1.

**Stubs**: Stubs are short lengths of tier 1 mains that are connected (usually via a tee) to a tier 2 or 3 ‘parent’ main. Downstream of the stub, the tier 1 main has previously been replaced by PE (generally by insertion) as part of the mandatory tier 1 iron mains replacement programme. These short tier 1 offtakes are often located at operationally difficult areas (e.g. road junctions), where the tier 2 or 3 parent main runs down a main road while the tier 1 offtake may be routed down a side road.

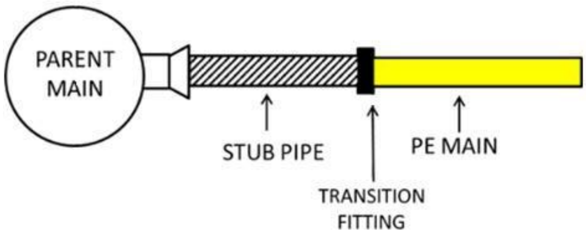



*Figure 13: Diagram of a Typical Stub*

Prior to RIIO-1, Cadent’s intention was to replace the tier 1 offtakes at the same time as the tier 2 and 3 parent mains, as this would be operationally more convenient. The initial HSE replacement policy required all iron mains (regardless of diameter) within 30m of a property to be replaced by 2032. However, following the interim review of the iron mains replacement policy, a modified Iron Mains Risk Reduction Policy (IMRRP) was introduced, in which replacement of the tier 2 or 3 parent main is not now mandatory. Where these mains are permitted to remain in service, the tier 1 offtake strictly contravenes the current replacement policy which mandates the replacement of all tier 1 iron pipe. The operational practicalities of replacing these short, isolated tier 1 sections, and associated costs, are significant due to their location and the need to intervene on the parent main for flow-stopping and cutting out of the parent main tee to remove the stub pipe.

For RIIO-1, the HSE does not require us to renew short stubs as defined by our REP/2 policy as these can be counted as fittings of the parent main. The maximum permitted length of a stub is proportional to the diameter of the parent main. For our largest diameter pipes a stub may be up to 11.5m long, for most diameters the permitted length is up to 3m. The HSE have accepted this approach as set out in our gas transporter safety case.

There has been an industry study ongoing to establish what the ‘correct length’ for short stubs should be. We have been talking regularly with the HSE on this issue. For our submission, we have not included any funding specifically to deal with stubs or changes in HSE agreed stub lengths. That is to say, we will maintain the definitions in our current REP/2 policy and present this to the HSE are part of our updated safety case.

**Note that if the HSE requires the replacement of stubs, i.e. if they reduced the maximum length of a stub allowed by our REP/2 policy or removed the classification of stubs as a fitting, then there will need to be a change to the submitted plan as there will be a delivery and cost implication.**

**Risers Associated with Mains Replacement**: Where replacement work is carried out on mains supplying risers (vertical pipelines supplying multi storey, multi occupancy buildings), an individual risk assessment is required to determine the condition of the riser pipe system. Riser pipe systems may be left in place only if their condition has been assessed as satisfactory. This is defined as the assets being below the riser replacement threshold and there being no signs of moderate or severe corrosion.

If the riser and its laterals (pipes linking the riser to individual properties) are in an unsatisfactory condition, rehabilitation (replacement or refurbishment) of the asset is required, such that issues are addressed, or the asset is permanently disconnected.

If the asset is satisfactory, then it can be transferred to the new mains being installed. However, if the asset is temporarily disconnected from the gas supply, then the person reconnecting the riser must satisfy themselves that the pipeline system is sound before reintroducing gas. To check if the riser is safe to connect an inspection and gas-tightness test will be required, which is carried out by means of pressure testing. If the asset fails the pressure test, or another issue is detected, the riser pipe system cannot be reconnected until it is shown to be sound, this will result in an unplanned interruption and follow-on work.

It is not prudent to disconnect a riser system as part of routine work whilst carrying the risk that we would not be able to reconnect it as the result of a failed pressure test. Particularly when replacement can, due to access issues, take several weeks. As such we are proposing that riser systems attached to mains which are due to be replaced will be pro-actively be replaced unless there is compelling evidence that the riser will pass a pressure test.

We estimated that around 3,700 risers have non-PE approach mains (the equivalent of a domestic service) needing to be addressed as part of the IMRRP that are not already covered by our safety-driven investment plans for risers. It is the current policy that these assets should be replaced with PE as part of mains replacement (as a service would be), which would require disconnecting gas from the riser and require a pressure test before reconnecting. The cost of this activity over RIIO-2 and RIIO-3 is likely to be *XXXX* per annum.

| | | | RIIO-2 | | | |
|---|---|---|---|---|---|---|
| **Risers** | **21/22** | **22/23** | **23/24** | **24/25** | **25/26** | **RIIO-2 Total** |
| **EoE** | 45 | 45 | 45 | 45 | 45 | **225** |
| **Lon** | 151 | 151 | 151 | 151 | 151 | **756** |
| **NW** | 78 | 78 | 78 | 78 | 78 | **390** |
| **WM** | 56 | 56 | 56 | 56 | 56 | **280** |
| **Cadent** | **336** | **336** | **336** | **336** | **336** | **1,650** |

*Table 18: Riser Volumes Associated with Mains*

| | RIIO-2 | RIIO-2 Total |
|---|---|---|

| (18/19 constant) | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | |
|---|---|---|---|---|---|---|
| EoE | | | | | | |
| Lon | | | | | | |
| NW | | | | | | |
| WM | | | | | | |
| Cadent | | | | | | |

Redacted due to commercial sensitivity

*Table 19: Riser Investment Associated with Mains*

The cost for this work has been included in the riser's element of the plan and can be found in table 4.08 of the BPDT. The investment has been included as part of our NARMs commitments.

**IMRRP (dynamic) Growth:** We have observed a level of growth in RIIO-1 of the IMRRP asset base. That is to say that the length of mains within scope of the IMRRP, which must be removed by 2032, increases. This can be caused by material reclassification (for example an asset record changing from steel to iron following excavation), the digitisation of an asset that was previously unmapped, or the development (encroachment) of buildings meaning that an asset now qualifies for renewal in the IMRRP programme (for example new houses being built near a gas main which was previously more than 30m from properties).

Analysing our asset base over RIIO-1 indicates that a network growth of 30km per annum can be expected. Our growth analysis by network shows the following:

| | Previously Unrecorded Assets (DR4s) (km) | <30m Boundary Changes (km) | Total (km) |
|---|---|---|---|
| EoE | 3.4 | 5.3 | 8.7 |
| Lon | 3.0 | 3.1 | 6.1 |
| NW | 2.1 | 7.5 | 9.6 |
| WM | 2.0 | 3.8 | 5.8 |
| Cadent | **10.5** | **19.7** | **30.2** |

*Table 20: Dynamic Growth by Network*

While encroachment will increase our remaining workload, this will be offset by diversions. That is the need to remove sections of our network because of third party developments such as new road layouts or domestic/commercial buildings. Where we are removing Tier 1 iron mains as a result of a diversion, the volume to be delivered by 2032 will decrease. We have analysed the volumes of iron replaced as a result of diversions in RIIO-1.

We can then offset this activity against the dynamic growth outlined above to better articulate the required change in RIIO-2. The table below shows the difference between our annual diversions and encroachment forecasts.

We have factored growth into our planning assumptions, considering the impact of diversions. That is to say we have increased the assumed length of work to be delivered by 2032 to reflect dynamic growth.

| | Km |
|---|---|
| **Average Annual Diversions** | -11.8 |
| **Annual Dynamic Growth** | 30.2 |
| **Net Dynamic Growth** | 18.6 |

*Table 21: Diversions Dynamic Growth Offset*

**Pace:** As part of our RIIO-2 solution assessment, we have investigated the risk that is posed by a 'hard stop' to the programme at the end of March 2032, the 'cliff edge', by analysing various delivery scenarios. The cliff-edge risk is created where a high volume of work (in this case 7,000m per day of replacement) is focused on a fixed delivery date and ends suddenly at that time: the difficulty of maintaining a large workforce which knows it will be disbanded. These scenarios have included the acceleration of delivery to allow a controlled ramp down of investment towards the end of the programme.

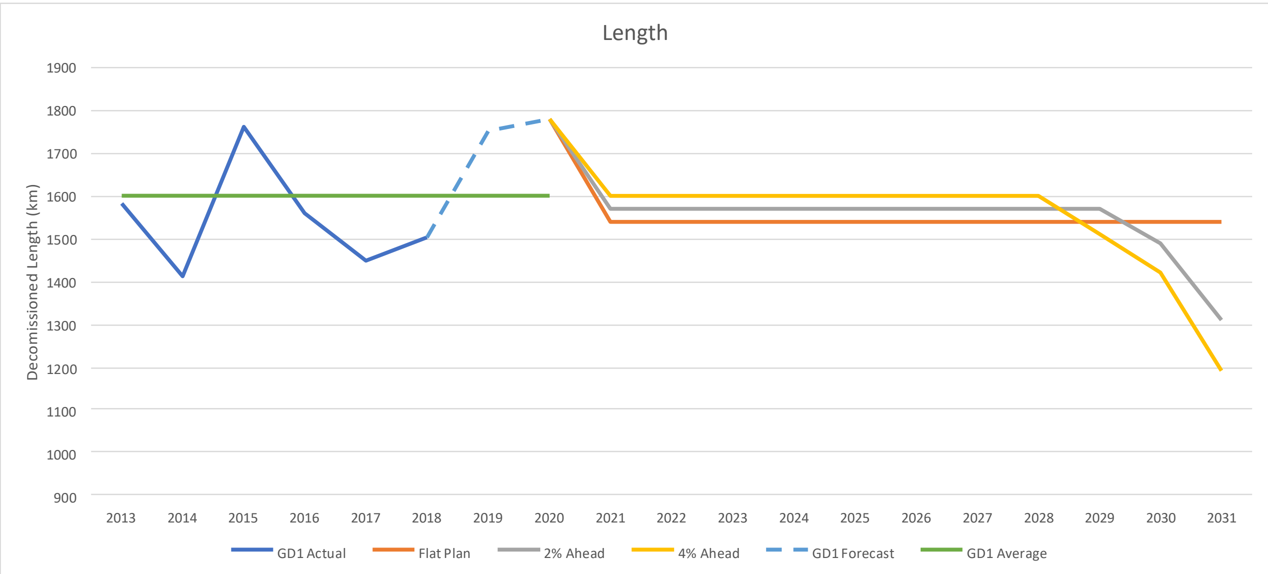



*Figure 14: IMRRP Delivery RIIO-1 and RIIO-2+ Options*

To set planned workloads for RIIO-2, we have considered three options:

| Option | | Description | RIIO-2 |
|---|---|---|---|
| 1 | Flat delivery to the end of the IMRRP programme | Pro-rata remaining work over the remaining 11 years of the programme, assuming work will run a flat delivery profile until 2032 with no workload taper. (1,538km per annum, excluding dynamic growth – HSE expectation) | Redacted due to commercial sensitivity |
| 2 | Marginally faster than flat run rate (2% ahead of flat) | Slower than RIIO-1 run rate at 1,568km but faster than flat. This is only marginally quicker than the flat delivery profile but allows for some flexibility to manage programme change. | |
| 3 | Continuation of the RIIO-1 run rate (4% ahead of flat) | Maintain the average RIIO-1 IMRRP delivery (1,600km). This is quicker than the flat and 2% delivery profiles, allows for more flexibility to manage programme change. | |

*Table 22: IMRRP Delivery Profile Options*

A linear approach (Option 1) to IMRRP mains gives a deliverable programme of delivery through to 2032. There is an opportunity in the six years after RIIO-2, to the end of the IMRRP programme, to profile works to prevent a cliff-edge effect in 2032.

The accelerated delivery of the IMRRP (Options 2 and 3) result in a greater IMRRP length in RIIO-2 than is mandated. There are several disadvantages to an accelerated programme:

- It is not possible to predict a robust cliff-edge impact as there are too many uncertain factors and as such it is difficult to quantify the relative benefits of accelerating work.
- Accelerating the programme sees us prioritising IMRRP over other safety or higher cost-beneficial works as resources are constrained.
- The work we will be delivering in RIIO-2 will be more difficult (e.g. due to diameter or location, as detailed later in this document) and additional increases in length presents a delivery risk.
- Increases in customer bills in the short term.

Having considered options, our planning assumption for RIIO-2 IMRRP is flat delivery through to the end of the programme of 1,538km per annum (excluding dynamic growth).

**Work Mix and Customer Benefits:** Using the modelling approach, the free-choice element of the plan (selection of specific pipes within mandated length) has been optimised alongside the other CBA investments. As part of delivering our safety commitment, we will therefore balance the delivery of other benefits to our customers, such as a reduced frequency of interruptions, to maximise total benefits in line with customer preferences. Following CBA analysis we tested potential service/price options during summer 2019 as part of business options testing. Customers selected the balanced benefits option, which aligns to the output chosen by the model as most cost beneficial. As a result, the model informs the work mix over the period: diameter, surface type, insertion rate and complexity.

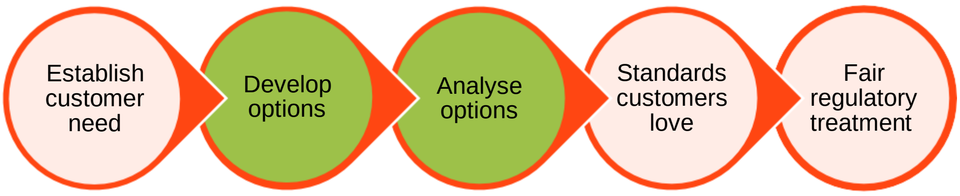
**≤2" Steel:** The majority of the ≤2" steel mains are not digitised, and therefore it is not possible to map the length we will encounter with routine mains renewal activity. Unlike our iron mains these assets are not recorded in our corporate GIS system ESRI. To calculate the volume of ≤2" steel that will be replaced in RIIO-2 we have used previous years' volumes as a function of the length of IMRRP tier 1 being renewed.

The average length of ≤2” steel per km of IMRRP used to develop the plan are:

| | km IMRRP (Y5/6) | km ≤2" Steel (Y5/6) | km ≤2" Steel /km IMRRP |
|---|---|---|---|
| EoE | 1,064 | 16 | 0.015 |
| Lon | 632 | 10 | 0.016 |
| NW | 653 | 18 | 0.027 |
| WM | 526 | 13 | 0.025 |

*Table 23: Length (km) of ≤2” Steel per km of IMRRP*

## 9.7. Business Case Outline and Discussion




### 9.7.1. Key Business Case Drivers Description

Within the boundaries set out above, there are multiple ways that the IMRRP can be prioritised and delivered. Each of the approaches will trade-off outputs (which include MRPS scores), efficiency of delivery, the benefit of repairs, leakage, interruptions and customer experience.

Our aim in developing the RIIO-2 plan is to deliver maximum value to consumers within the limits of work mandated by safety legislation. As discussed, we have developed an advanced CBA model based on the NOMs methodology, which allows us to assess the impacts of mains renewal options.

The CBA model understands the impact of investment decisions on several metrics:

- **Risk removed (MRPS Risk)** is calculated from the MRPS scores of the pipes selected.
- **Repairs removed** is based on the reduction in the number of repairs.
- **Customer Interruptions** is based on the interruptions experienced by customers
- **Carbon (environment)** is based on the leakage model.

This analysis provides a robust quantification of options based on known values and formed the basis of our July submission (which included presentation of each of the modelled options).

To complement this approach, we also undertook qualitative research with customer through summer 2019 to ensure that we had a fully rounded view of customer preferences. As part of customer engagement, we carried out several customer consultation sessions where we asked customers to describe their preference in how we should prioritise mains replacement and discuss how they would like to phase costs. This combination of both qualitative and quantitative approaches to analyse options demonstrates best practice in decision making. In the business options testing customers were presented with five options with percentage reduction benefits for each (safety, disruption, environment, balanced and balanced smooth cost), they were asked to discuss their preferences and to choose their preferred option (results are presented in Appendix 7).

For costs we explained that we are seeing a change in the proportion of different types of work on IMRRP assets when compared to RIIO-1 and that by 2032 all of the assets in scope of the programme will need to be renewed. However, we have choice in the order in which we deliver them. We presented options on spreading costs through time, asking customers where they had a preference for a smooth bill profile or for delivering lower-cost work in RIIO-2 and higher-cost work in RIIO-3.

Redacted due to commercial sensitivity

*Figure 15: RIIO-2 Unit Cost Profiles (Indicative as part of customer research)*

Overall, when replacing mains as part of the IMRRP a balanced programme and a balanced programmed with smooth costs over RIIO-2 and RIIO-2 were the most popular. These two options combined accounted for half of the overall vote.

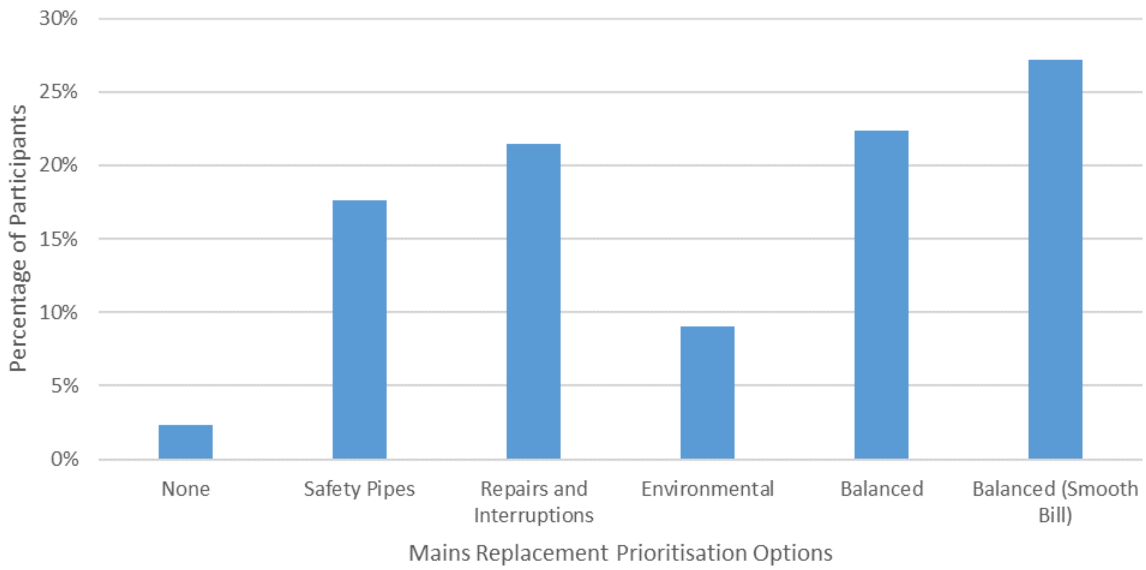



*Figure 16: Mains Replacement Prioritisation Options Consultation Results*

This preference aligns with the results of our CBA analysis. We have therefore developed a plan which considers the benefit to the environment, repairs, safety and customer performance based on their respective valuations.

## 9.7.2. Business Case Summary

This section sets out the CBA of investment to replace mains as part of the IMRRP. Replacement of these assets is an absolute duty under the requirements of IMRRP and as such does not require an economic justification. However, it is useful to consider the investment from an economic perspective, analysis shows that the investment is cost beneficial with a large NPV.

The table shows the present value of costs for each network for the IMRRP investment. Costs and benefits are discounted and shown in present value (PV) terms in line with Ofgem requirements and the HM Treasury Green Book. The costs for each option are based on the five years of investment in RIIO-2.

The CBA results below include the costs of completing the IMRRP including ≤2" Steel, associated services and the additional reinforcement work to enable insertion. We have not included investment in associated MOBs (or calculated benefits) as the number of assumptions required to value the benefit would be large and the benefits are on the MOBs asset estate, not on the mains.

The table below shows the discounted present value of costs for each option to 2071:

| Option No. | Option description | PV Expenditure & Costs | PV Environment | PV Safety | PV Reliability | PV Other | Total PV | NPV |
|---|---|---|---|---|---|---|---|---|
| 0 | **Reactive Only** | | | | | | | |
| 1 | **Flat IMRRP (Chosen) (RIIO-2 only)** | | | | | | | |
| 2 | **Flat IMRRP without superstrings (RIIO-2 only)** | | Redacted due to commercial sensitivity | | | | | |
| 3 | **Flat IMRRP without insertion benefits (RIIO-2 only)** | | | | | | | |
| 4 | **Flat IMRRP (RIIO-2 and RIIO-3)** | | | | | | | |
| 5 | **Flat IMRRP exc. WTP** | | | | | | | |

*Table 24: PV and NPV for IMRRP scenarios*

**Note:**

- PV expenditure and costs show the discounted sum of proactive investment (replacement or refurbishment costs), maintenance, repairs and other ongoing opex costs. Proactive investment has been considered over RIIO-2, although we have included some scenarios that consider ten years of investment: RIIO-2 and RIIO-3. All other financial costs are considered over the full period to 2071. All financial costs are discounted using the Spackman approach.
- PV environment shows the discounted sum of leakage and shrinkage, using the base case cost of carbon.
- PV safety shows the discounted sum of the risk of fatalities and injuries, as valued using Ofgem's stated costs per fatality and cost per non-fatal injury.
- PV reliability shows the discounted sum of interruption risk, as valued using our own valuation research (e.g. the willingness to pay study into the cost of interruptions to homes and businesses).
- PV other shows the discounted sum of any other impacts, as valued using our research into the cost of property damage and transport disruption.

Costs are presented as negative values. The total PV is the summation of the five categories of costs.

The baseline has been specified as the minimum investment position. The NPV for each option is computed as the difference between the total PV for each option and the total PV for the baseline. A positive NPV means an option has less cost associated with it relative to the baseline and is therefore cost beneficial. The option with the highest positive NPV is the most cost-beneficial of the options considered.

The table below summarises the cost-benefit results for each option. This provides the NPV for the option (computed as the difference in total PV relative to the baseline) – to show which options are cost-beneficial or not. We also include the payback period and the ratio of NPV to RIIO-2 investment to understand how much NPV per £ spent in RIIO-2 the options generate.

| Option No. | Option description | NPV - Relative to baseline *XXXX* | Cost beneficial | Payback Year | RIIO-2 spend (Replace, Refurb) *XXXX* | Ratio NPV to RIIO-2 replace/ refurb spend | RIIO-3 spend (Replace, Refurb) *XXXX* | Ratio NPV to RIIO-2 and RIIO-3 (Replace, Refurb) *XXXX* |
|---|---|---|---|---|---|---|---|---|
| 0 | Reactive Only | | | | | | | |
| 1 | Flat IMRRP (Chosen) (RIIO-2 only) | | | | | | | |
| 2 | Flat IMRRP without superstrings (RIIO-2 only) | | Redacted due to commercial sensitivity | | | | | |
| 3 | Flat IMRRP without insertion benefits (RIIO-2 only) | | | | | | | |
| 4 | Flat IMRRP (RIIO-2 and RIIO-3) | | | | | | | |
| 5 | Flat IMRRP exc. WTP | | | | | | | |

*Table 25: Cost-Benefit Summary for All Scenarios*

**The table above shows CBA results:**

- The NPV for each option is computed as the difference between the total PV for each option and the total PV for the baseline. A positive NPV means an option has less cost associated with it relative to the baseline and is therefore cost-beneficial. The option with the highest positive NPV is the most cost-beneficial of the options considered.
- Payback shows the year when the sum of costs associated with an option is lower than that of the baseline (i.e. this is the point at which the option can be considered to be cost-beneficial). This is driven by the profile of the costs and the capitalisation rate.
- The table shows the RIIO-2 proactive expenditure. If applicable the RIIO-3 proactive expenditure is also shown.
- The ratio of NPV to RIIO-2 spend shows how much NPV per £ spent in RIIO-2 the options generate. A positive figure means the investment is cost-beneficial. The higher the figure the more cost-beneficial the option.
- We have also provided the ratio of NPV to the combined RIIO-2 and RIIO-3 spend for those options where ten years of proactive expenditure has been considered.
- In assessing these CBA results, we recognise we need to balance NPV, payback, and the ratio of NPV to proactive spend, alongside other considerations such as affordability and compliance with legal standards and obligations.

We recognise our absolute duty to comply with legal standards, but we have also balanced NPV, payback, the ratio of NPV to proactive spend, and affordability in reviewing and finalising our plans.

Our proposed investment, Option 1, seeks to maintain the level of risk and comply with the HSE mandated programme of works for these assets. In developing our plan, we have reviewed a number of investment options: our preferred option represents good value for money for our customers. It is very cost beneficial, as indicated by the high NPV and the robust ratio of NPV to spend.

We have considered the option of investing to meet our obligations without superstrings (Option 2). This option shows that investment is hugely more expensive resulting in a much longer payback period. The cost increase is significant and is not as affordable or efficient. Given the importance of efficient and affordable bills to our stakeholders and customers, we have discounted this option: it is not our preferred option as it delivers less value per £ spent and is very expensive. The cost increase is very high when not using superstrings as the cost of mobilisation is considered for every job, whereas superstrings allow the modelling approach to group the renewal of neighbouring assets together.

Option 3 shows that even without insertion benefits our investment is cost beneficial and value for money to our customers. This option confirms that our chosen option delivers value for our customers and stakeholders - even if insertion benefits do not occur.

Option 4 shows that the IMRRP investment in RIIO-2 and RIIO-3 is cost beneficial. This option demonstrates that our preferred option delivers high levels of value per £ spent.

Finally, Option 5 shows the preferred option excluding the customer WTP for interruptions. This is used to show our preferred plan is cost beneficial excluding the benefits from avoiding customer interruptions, i.e. the safety and environmental benefits from our preferred investment is cost beneficial and value for money for our customers.

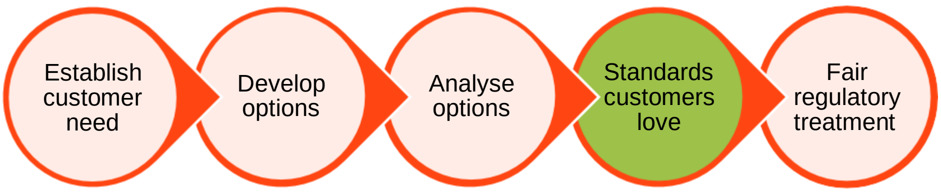
The table below shows the results by region for the preferred Option 1:

| | NPV | Cost benefit | Payback | RIIO2 spend | Ratio NPV to RIIO-2 replace/refurb spend |
|---|---|---|---|---|---|
| **EoE** | | Cost Beneficial | | | |
| **LON** | | Cost Beneficial | Redacted due to commercial sensitivity | | |
| **NW** | | Cost Beneficial | | | |
| **WM** | | Cost Beneficial | | | |
| TOTAL | | **Cost Beneficial** | | | |

*Table 26: Cost-Benefit Summary for the Chosen Scenario by Region and Type*

The options deliver benefits across the monetised-risk categories: ‘safety’, ‘environment’, ‘financial’, and ‘other’. The key societal benefits centre on reductions in safety risk. CBA shows that investment in the IMRRP is cost-beneficial in all networks with investment paying back between 2035 and 2043 (9-17 years).

## 9.8. Preferred Option Scope and Project Plan




The scenario assessment above outlines our approach to prioritising the tier-1 mains workload during the RIIO-2 period. The following section demonstrates how the selected scenario has subsequently been translated into the workloads and output commitments within our business plan.

### 9.8.1. Preferred Option

Our preferred option is to deliver the IMRRP on a base-flat programme, factoring in dynamic growth and the impact of diversions. We do not need SEEDs in RIIO-2, due to the flattening of the MRPS risk score, and we propose the continuation of our current stubs policy; therefore, no additional spend for SEEDs or stubs are proposed. Our pipe selection will be balanced benefits in line with customer preferences and our CBA.

## 9.8.2. Asset Health Spend Profile

On the basis that delivering a flat run rate until the end of the programme is the best option, our planned workloads, with the inclusion of dynamic growth (reduced volume considering diversion) are as follows (this table excludes associated ≤2" Steel, services and associated MOBs spend):

| Km Abandoned | RIIO-1 | | | RIIO-2 | | | | | RIIO-2 Total |
|---|---|---|---|---|---|---|---|---|---|
| | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | |
| **EoE** | 589.6 | 611.6 | 611.6 | 561.2 | 561.2 | 561.2 | 561.2 | 561.2 | **2,806** |
| **Lon** | 316.0 | 335.0 | 335.0 | 309.3 | 309.3 | 309.3 | 309.3 | 309.3 | **1,546** |
| **NW** | 330.1 | 430.8 | 458.8 | 388.6 | 388.6 | 388.6 | 388.6 | 388.6 | **1,943** |
| **WM** | 259.9 | 367.2 | 366.2 | 297.9 | 297.9 | 297.9 | 297.9 | 297.9 | **1,490** |
| **Cadent** | **1,496** | **1,745** | **1,772** | **1,557** | **1,557** | **1,557** | **1,557** | **1,557** | **7,785** |

*Table 27: IMRRP Volumes (Abandoned)*

The investments associated with these mains are set out below. In total, we are proposing to invest *XXXX* over RIIO-2 on the IMRRP mains.

| (18/19 constant) | RIIO-1 | | | RIIO-2 | | | | | RIIO-2 Total |
|---|---|---|---|---|---|---|---|---|---|
| | 18/19 | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | |
| **EoE** | | | | | | | | | |
| **Lon** | | | | | | | | | |
| **NW** | | | | | | | | | |
| **WM** | | | | | | | | | |
| **Cadent** | | | | | | | | | |

*Table 28: IMRRP Mains Investment*

Based on the length of tier-1 IMRRP activity planned for RIIO-2 the length of ≤2" steel is detailed in the table below.

| Km Abandoned | RIIO-1 18/19 | RIIO-1 19/20 | RIIO-1 20/21 | RIIO-2 21/22 | RIIO-2 22/23 | RIIO-2 23/24 | RIIO-2 24/25 | RIIO-2 25/26 | RIIO-2 Total |
|---|---|---|---|---|---|---|---|---|---|
| EoE | 7.9 | 6.9 | 4.9 | 8.1 | 8.1 | 8.1 | 8.1 | 8.1 | **40.7** |
| Lon | 4.2 | 0.1 | 0.0 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 | **24.5** |
| NW | 13.9 | 38.4 | 45.9 | 10.4 | 10.4 | 10.4 | 10.4 | 10.4 | **52.0** |
| WM | 7.7 | 18.5 | 14.4 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | **35.9** |
| Cadent | **33.7** | **63.9** | **65.2** | **30.6** | **30.6** | **30.6** | **30.6** | **30.6** | **153.1** |

*Table 29: ≤2" Volumes (Abandoned)*

The investments associated with these mains are set out below. In total, we are proposing to invest *XXXX* over RIIO-2 on ≤2" steel mains.

| (18/19 constant) | RIIO-1 18/19 | RIIO-1 19/20 | RIIO-1 20/21 | RIIO-2 21/22 | RIIO-2 22/23 | RIIO-2 23/24 | RIIO-2 24/25 | RIIO-2 25/26 | RIIO-2 Total |
|---|---|---|---|---|---|---|---|---|---|
| EoE | | | | | | | | | |
| Lon | | | | | | | | | |
| NW | | | | | | | | | |
| WM | | | | | | | | | |
| Cadent | | | | | | | | | |

*Table 30: ≤2" Mains Investment*

## 9.8.3. Investment Risk

A programme risk table is included in Appendix 10.

As discussed in Section 8, we have developed robust unit costs based on our actual delivery costs in RIIO-1. Since the IMRRP is an asset-defined programme of works, and we know what pipes we will be replacing, we have a high confidence in the costs we are proposing for RIIO-2.

However, for RIIO-2, we are seeing a significant shift in the proportion of different types of work on IMRRP assets when compared to RIIO-1. As discussed in previous sections of this document, the characteristics of the workload, such as volume, location and type are the most critical drivers of the costs within the programme.

For RIIO-2 IMRRP, we are dealing with larger diameter bands; the average work length (length per scheme) is decreasing, and the amount of work required in carriageways is increasing (as shown in the table below and in our BPDTs). This change in the characteristics of the workload, combined with the change in insertion rates, has led to an increase in the overall difficulty of delivering the IMRRP. This change in average workload characteristics will impact on the number of resources required to deliver the programme.

| | EoE | | Lon | | NW | | WM | |
|---|---|---|---|---|---|---|---|---|
| | RIIO-1 | RIIO-2 | RIIO-1 | RIIO-2 | RIIO-1 | RIIO-2 | RIIO-1 | RIIO-2 |
| **Average Scheme Length (m)** | 757 | 559 | 760 | 481 | 710 | 411 | 611 | 457 |
| **Average Diameter (mm)** | 113 | 132 | 119 | 136 | 111 | 131 | 120 | 139 |
| **Work in Road (%)** | 17.9% | 30.7% | 27.1% | 33.4% | 15.2% | 27.2% | 27.7% | 33.1% |

*Table 31: IMRRP Work Mix Change RIIO-1 – RIIO-2*

To mitigate some of this increase in cost, we have applied challenging efficiencies to the plan.

As discussed in section 9.6 there are also risk associated with the scope of the programme following confirmation of the HSEs position. If the HSE require us to deliver seed or stub renewal, then there would be delivery and cost implications. We would lose opportunities to produce the best 'super string schemes' and, as such, average scheme length would decrease and costs would rise.

## 9.9 Regulatory treatment

In Ofgem's 'RIIO-2 Sector Specific Methodology Decision' it is confirmed that the IMRRP programme is classed as mandatory repex, including the replacement of Tier 1, associated non-PE services pipes and associated steel pipe less than 2" in diameter.

Ofgem are proposing the introduction of a Price Control Deliverable (PCD) for Tier 1 iron mains. We agree with Ofgem's view that a PCD achieves a clear link between workloads, outputs and costs and provides a transparent mechanism for closeout of the control period.

Ofgem will set a target for the total kilometres of Tier 1 iron mains abandoned over RIIO-GD2. This will include qualifying cast iron, ductile iron and spun iron mains, but will not include steel pipe less than or equal to 2" in diameter.

Ofgem will put in place a requirement for networks to deliver a specific diameter band mix within Tier 1, as a condition of the Tier 1 PCD. This mix will be based on each network's forecast of workload volumes. Ofgem will allow a tolerance band around each diameter band target. We are open to working with Ofgem on the exact form of the diameter band restriction.

# 10. Investment Methodology – Pipes Above Safety Threshold (PAST)

# 10.1. Introduction

Safety is a primary focus for our customers as well as a mandatory standard that we must deliver. The Pipeline Safety Regulations (1996) apply to all materials and diameters of distribution mains.

Our proposed approach for RIIO-2 is to continue the IMRRP programme and, where appropriate, renew non-IMRRP assets where they are above safety-risk thresholds. Where assets are above threshold and are awaiting renewal, we must ensure that we have appropriate controls in place to mitigate risks until replacement is completed.

We understand the safety risks presented by the different elements of our pipe network and the mandatory safety standards which we must achieve.

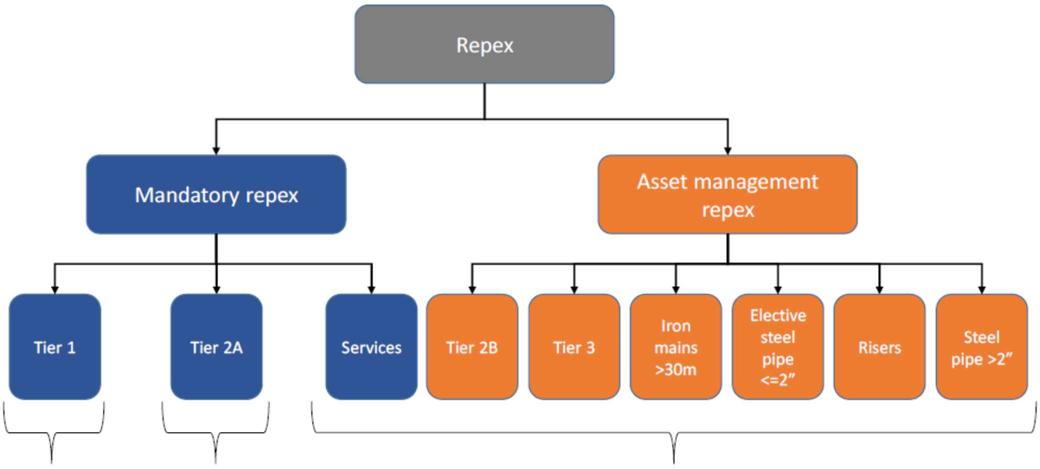
Several different safety mechanisms have operated during RIIO-1 (the IMRRP, ALARP, SEED and RAT). Within these mechanisms is a minimum risk threshold agreed with the HSE – a level which ensures no individual should be exposed to a risk of more than 1 in 1,000,000[5] of fatality as a result of being within 30m of our distribution assets. For RIIO-2, we will work towards ensuring this minimum standard <u>for all pipes</u> by developing appropriate safety approaches to different cohorts of pipe (explained in detail over the following pages). This evolution puts assessment of safety risk, rather than pipe material at the centre of decision making.

1. Mandatory Safety Mains (introduction of a pipe and societal safety threshold):
    - **Tier 1 iron mains:** remediation of tier 1 iron pipes above safety thresholds, an enhancement of the current RIIO-1 ALARP approach (a more granular assessment of risk). There is no additional length associated with this above the tier 1 renewal as detailed in the sections above. That is to say, work delivered via this mechanism will count towards the IMRRP target volume.
    - **Tier 2a iron mains:** remediation of tier 2 iron pipes above safety thresholds – for RIIO-2 we are proposing an enhancement to the RIIO-1 Risk Above Threshold (RAT) threshold setting through the introduction of pipe and societal thresholds.

2. Non-IMRRP Safety Mains (a new approach for RIIO-2):
    - **Tier 3 Iron and Asbestos:** introduction of pipe and societal safety thresholds and renewal if the pipe is above safety thresholds
    - **Steel:** introduction of pipe and societal safety thresholds with a qualification based on material standards (linked to age). Steel will be promoted for renewal where the asset is above a safety threshold and the asset is in the high-risk band.
    - **Risk management:** enhanced monitoring regime (opex) for all pipes above a safety threshold.

This is an evolution of the position set out by Ofgem in its December 2018 consultation. Ofgem's diagram below shows a useful separation of 'mandatory' repex and 'asset-management' repex, which we support. However, the mandatory repex category, as illustrated, is only focused on the current HSE enforcement policy and does not account for other mandatory safety work driven by the Pipeline Safety Regulations (1996). Reviewing MRPS risk scores it can be seen that there is now a case for carrying out additional safety driven work outside of the mandated replacement programme. We therefore propose that another mandatory repex box should be added to cover 'other mandated repex'. As with tier 2a, this would be based on a volume driver, allowing companies to recover investment driven by changes to MRPS risk scores.

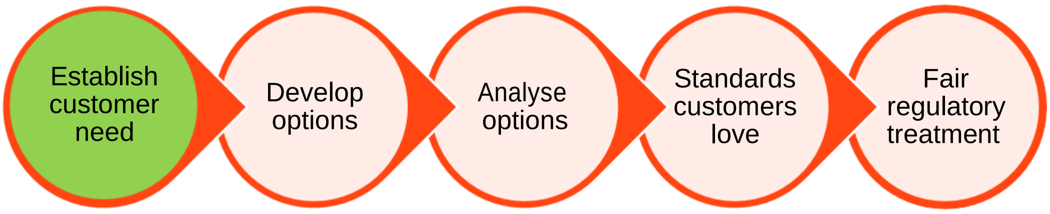
[5] http://www.hse.gov.uk/research/rrpdf/rr888.pdf




| | | | |
|---|---|---|---|
| **Outputs proposals under consideration** | PCD | No output target, volume driver | PCD or NARMs only |

Figure 17: Repex Breakdown

As with the IMRRP, although the work is primarily driven by regard to safety, it also delivers wider customer and societal benefits, including reduced repairs (cost and disruption), reduced leakage and reduced interruptions to supply.




## 10.2. Equipment Summary

Included within the MRPS are iron, steel and asbestos mains of all tiers with a risk score where they are within 30 metres of a building. There are 5,569km of non-PE assets which have MRPS risk scores and are not part of either the current HSE enforcement programme or subject to the tier 2 safety thresholds. These assets account for 16% of total non-PE distribution mains operated by Cadent by length.

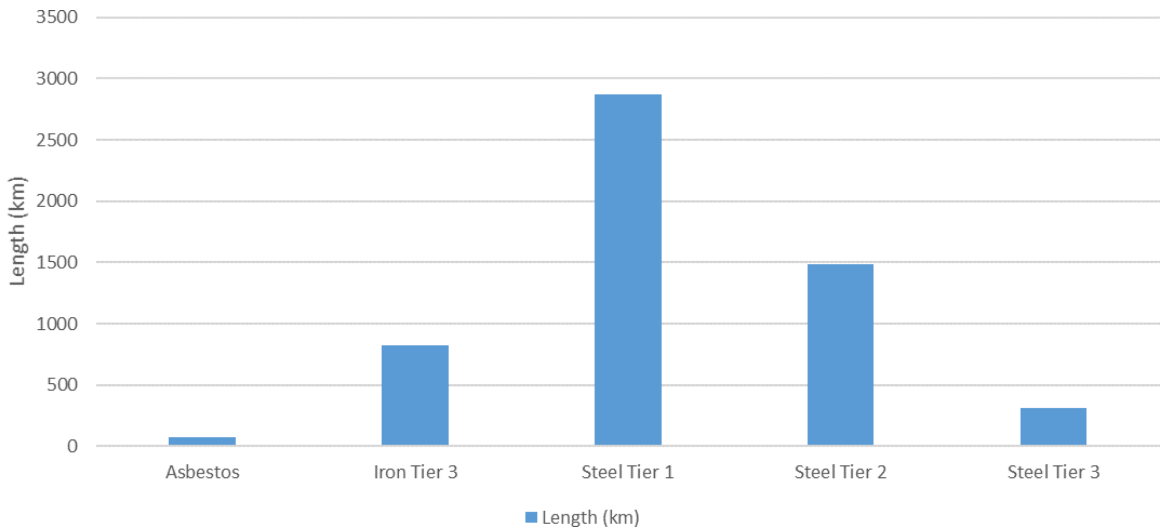



*Figure 18: Non-IMRRP Pipes with MRPS Risk Scores (2019 Extract)*

Note: Within scope of the PAST safety work is a small length of iron tier 1 (6km), selected on safety grounds, which is classified as 2" iron. We do not include 2" iron in the IMRRP as, when we excavate these assets, they tend to be found to be 2" steel, not iron. For the purposes of completion of the Business Plan data tables this length has been included in the iron >30m section.

*Picture 3: A Steel Main*

## 10.3. Problem Statement

Although there is not an HSE enforcement policy for assets outside of the IMRRP scope, we must comply with our obligations under the Pipeline Safety Regulations: “The operator shall ensure that a pipeline is maintained in an efficient state, in efficient working order and in good repair” (Regulation 13) and as such have a need to consider where safety-driven investment is required.

For RIIO-2, the HSE has confirmed in stakeholder meetings that iron pipes in either tier 1 or tier 2 should be replaced based on the output from the MRPS risk model, whereby, all mains exceeding an agreed safety threshold (1 in a 1,000,000 chance of a fatality) will be subject to replacement. This is an absolute duty within PSR (1996) - the regulation must be adhered to regardless of the time, effort and cost of doing so.

In the preparation for RIIO-2, several industry studies have been carried out, including a cross GDN sponsored study conducted by Advanced Engineering Solutions LTD (AESL) to assess the safety risk associated with steel mains. Conclusions from these reports strongly suggest that the risk on steel assets needs to be addressed as the risks posed by these assets has increased during RIIO-1 and will continue to do so. Cadent has discussed this issue with the HSE, and it has asked us to put forward evidence-based proposals on how the issue can best be addressed.

From a legislative and customer perspective, the material and diameter of pipes are not relevant. It is the safety risk, the chance of explosion, which matters. We have therefore developed a response focused on safety and not asset characteristics. Although our understanding of an asset’s performance is relevant in the calculation of safety risk, legislation is clear that we have an absolute duty to protect our customers (Regulation 13 PSR).

We operate an emergency repair service which allows us to respond quickly to a reported gas escape. However, in focus groups, customers have told us that they wanted more proactive checking of pipes, such as regular safety checks and pressure monitoring, to predict problems before they occur. Safety, including the prevention of emergency situations, was consistently highlighted as the most important or joint-most important priority.

### 10.3.1. Narrative Real-Life Example of Problem

Assets within 30 metres of a building have the potential to cause a major incident, leading to serious injury or loss of life. See Section 9.3.1. for a case study of an incident which occurred in 2010. This occurred on a 9” iron main (this main would have been in scope of the RAT approach).

### 10.3.2. Spend Boundaries

The spend detailed in this section is for the replacement of distribution mains assets which are above the agreed safety threshold.

## 10.4. Probability of Failure

The method by which a gas main fails largely depends on the material from which the asset is made. Cast iron and spun iron pipes are brittle and therefore their failure mode is to fracture either along the pipe length or circumferentially (corrosion and joint failures are also observed). Ductile iron pipes are less brittle; therefore, fracture is less common; however, they do corrode in localised areas (1-2m sections) which can lead to gas escapes. As with ductile iron pipes, steel pipes also tend to corrode with age but are much more resistant to fracture failures.

Analysis of the number of repairs, taken from core company systems, shows that the number of failures on steel mains is increasing over time as the assets deteriorate. The number of failures shows some yearly variation, which is expected due to the impacts of weather and other external effects.

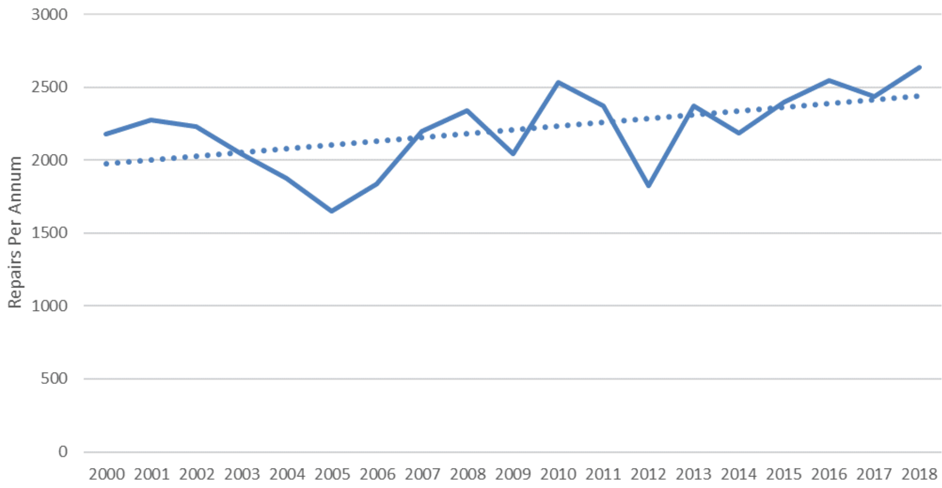



*Figure 19: Steel Main Gas Escapes Through Time*

### 10.4.1. Probability of Failure Data Assurance

The MRPS system is being used to inform the safety workloads for PAST pipes. As discussed, the industry MRPS model is in the process of being updated. We have used the latest available data to inform the plan. There is a degree of uncertainty in this data, so we have proposed an uncertainty mechanism to allow for any upward changes to the stated volumes and deal with dynamic growth.

## 10.5. Consequence of Failure

All assets that are within 30m of a building have a risk score calculated by the MRPS. The risk score represents the number of incidents (property explosions) per annum we would expect from these assets.

Data from the MRPS system shows that the number of incidents per annum that we would expect from steel assets is greater than what we would expect from iron mains. This is in a large part due to the focused IMRRP for iron mains – i.e. we have been investing significantly for nearly 20 years to reduce iron risks, whereas steel has not been pro-actively replaced.

The MRPS risk scores for assets outside the scope of the IMRRP now have a greater incident risk than the assets within the IMRRP.

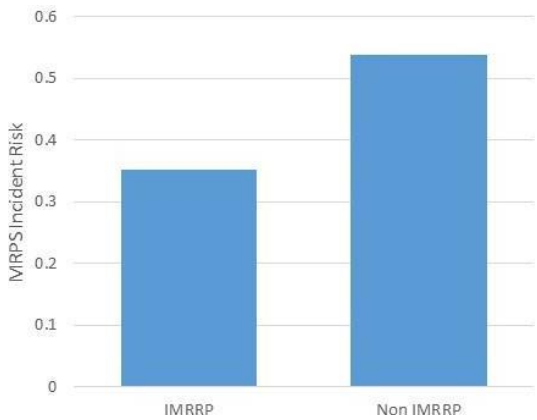



*Figure 20: Indicative MRPS Incident Rate for IMRRP and Non-IMRRP Assets*

All GDNs are currently updating the coefficients that are used in the MRPS model. The MRPS model was last updated in 2013 and the current update will ensure that the risks calculated in the system reflect the performance and safety risks that the assets have today.

For the business plan, we have used draft MRPS scores to calculate the level of safety investment required for Cadent. We have made this decision as the risks being calculated by the updated MRPS coefficients are more representative than the scores being produced by the 2013 coefficients.

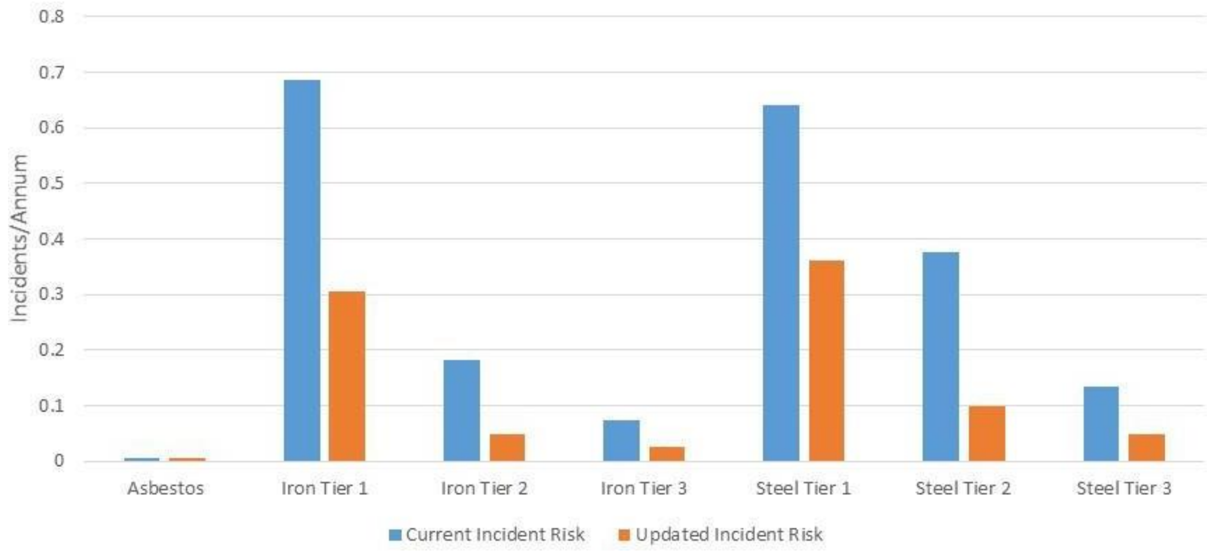


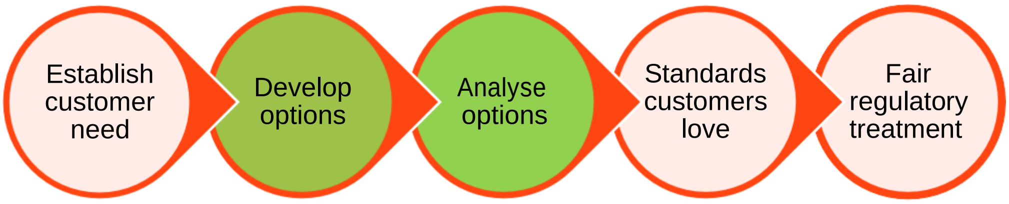

*Figure 21: Indicative change in incident risk following MPRS Update*

The reason for the change in the MRPS risk score is that there has been a reduction in the frequency of fatal explosions and this change impacts the industries calculation of risk. The previous values would suggest approximately 2 people would be killed by gas explosions each year from Cadent's assets, the new figures suggest on average 0.9 people per year.

**MRPS will be updated formally towards the end of the 2019/20 financial year. Only at this point will the exact risk figures for each asset be known. Therefore, the volumes of safety-driven work detailed below are based on our best estimate at this stage.**

To date, there have been no incidents caused by non-iron mains. Our investment proposed for RIIO-2 is to tackle the mains with the worst scores to ultimately eliminate the risk of any incident and subsequent fatality being caused by these assets.

## 10.6. Options Considered




**<u>Setting Appropriate Risk Thresholds</u>**

The absolute risk of each iron gas pipe is currently modelled using MRPS, which predicts the probability that each pipe will produce an incident. It does not directly predict individual risk exposure, rather the likelihood that a property is damaged or destroyed by an explosion (and additional step in the risk assessment assesses the number of individuals that will be killed or injured within the property). The MRPS risk score for each pipe is defined as the probability of an incident per km per year. All four GDNs use the same approach to calculate the pipe risk scores.

HSE has stated that a 1 in 1,000,000 probability per annum of an individual in close proximity to a main (defined as being within 30m) becoming a fatality should be used as a guideline for the broadly acceptable boundary. It is then the responsibility of each GDN to define a risk threshold above which pipes must be prioritised for replacement.

In RIIO-1, we have set risk thresholds for tier 1 (ALARP) and tier 2 iron (RAT) <u>using building density at a network level</u> and fatality rate to determine the risk threshold. In preparation for RIIO-2, Cadent commissioned international accredited registrar Det Norske Veritas Germanischer Lloyd (DNV GL) to review our approach to setting thresholds, and they recommended the following modifications to our approach for RIIO-2:

1. Risk threshold should be set at a pipe level considering the individual pipes' property density (this gives a more accurate assessment than applying a network factor[6]).
2. A secondary societal risk score should be introduced – this sets an upper-risk limit for all pipes, based on the acceptable risk level from a societal point of view.
3. The fatality rate used in RIIO-1 should be modified to an individual's risk exposure.

We have chosen to accept the first two of DNV GL's proposals.

With regards to the third point, in our detailed review, the agreed mathematics for assigning risk in RIIO-1 was identified as being incorrect. This is related to the probability of a building being destroyed and the probability of people in that building being killed rather than an individual's exposure to being killed. This small mathematical error means that the threshold set for RIIO-1 was lower than it should have been (a set of stricter safety thresholds). We could update the modelling for RIIO-2 but this would create a small increase in the threshold and therefore we would leave some higher risk pipes in the ground which using the RIIO-1 rules would have replaced. As such, we have chosen to continue using the fatality-rate approach rather than update it to an individual's risk exposure. This is on the basis that we have been using the fatality rate to set risk thresholds in RIIO-1 and changing this value will loosen the safety thresholds customers have benefited from in RIIO-1. If we were to use the revised individual risk value the safety work (including tier 2a) would be

[6] i.e. it is more correct to assess the actual property density on a specific street in Norwich, than to apply the average property density for the whole of east of England. This increased accuracy is enabled by improved data analytics and greater computing power.

approximately 20% shorter in length. At the simplest level our decision to keep the current value rests on the fact that the HSE and customers would not welcome a reduction in safety standards.

See Appendix 2 for more details on setting risk thresholds.

**Mandatory T2a Iron Mains**

Tier 2 pipes scoring above their risk thresholds (as defined above) will be renewed over RIIO-2 as part of the approved PSR regulation 13A IMRRP programme. All pipes identified for remediation will be physically decommissioned or replaced as this is currently the only method of addressing the risk that the HSE accepts. This continues the approach taken in RIIO-1.

The replacement of tier 2 iron pipes above the safety threshold is a mandatory programme and therefore there is no deferral or do-nothing option.

Tier 2 pipes scoring below the risk thresholds may still be subject to intervention. Funding for this additional pipe replacement will be determined via cost-benefit assessment as part of the RIIO-2 process, resulting in additional levels of risk removed and other customer benefits. That is to say a pipe may be selected for replacement based on the CBA, part of the benefit achieved will be a safety benefit. This is discussed further in the Enhanced Benefits section of this document.

**Non-IMRRP Safety Mains – Identifying our absolute duty requirements**

There are 5,569km of non-PE assets which have MRPS risk scores and are not part of an HSE mandated IMRRP programme; 84% of these assets are steel. We have an absolute duty to maintain these pipes to ensure that they operate in efficient working order and in good repair.

Prior to RIIO-1, the incident risk associated with iron mains was viewed as a higher priority than that associated with steel due to the number of incidents caused by these assets – hence the introduction of the mandatory IMRP. Over the course of the IMRP and IMRRP, the iron risk, although still not acceptable, has been reduced significantly. Going into RIIO-2, based on the current MRPS scores the safety risks posed by iron vs. other materials are similar. This has led us to review the safety risks associated with non-IMRRP assets and propose a new way forward.

The MRPS risk score associated with these assets has been reviewed by DNVGL which has stated that "the mathematical structure and coefficients of the Steel Risk Model are as up to date as the other models used for mandatory replacement. The Steel Risk Model is therefore a valid basis for the risk assessment of steel distribution pipes within 30m of buildings"; see Appendix 3. The comparison of incident rates in the figure above is appropriate: the basis of calculations is in the same currency.

Consistent with the HSE agreed approach to tier 2a iron mains, we have calculated risk thresholds for non-mandatory mains at a level which ensures no individual should be exposed to a risk of more than 1-in-1,000,000 of fatality as a result of being within 30m of such assets. See Appendix 2 for more details on setting risk thresholds.

Applying these risk thresholds to the draft MRPS risk scores identifies 408km of non-IMRRP safety mains above the risk threshold across our four networks. Most of these assets are tier 1 steel. <u>If these pipes were iron, we would be mandated to replace them within the ALARP or RAT mechanism because their safety score was so high</u>.

The 408km of non-IMRRP assets above the risk threshold have an associated incident risk (the number of explosions that can be expected from these assets per annum) of 0.35. This is high, and it accounts for 39% of the incident risk across all assets in MRPS for the whole of Cadent. On this basis, a safety renewal programme for these assets is an absolute duty.

In the interest of deliverability, keeping customers safe and cost, we have considered approaches for prioritising the renewal of non-IMRRP mains for RIIO-2. A do-nothing scenario for these assets is not appropriate as customers would be exposed to unacceptable levels of risk. We have carried out a review of the characteristics of the materials that are in scope of our safety approach and propose the following prioritisation of non-IMRRP safety investment:

- Prioritisation of replacement for steel pipes above the safety threshold based on MRPS risk score and material standards linked to age (the material standard criteria is explained below)
- Renewal of all asbestos and iron tier 3 pipes above the safety threshold

Regarding non-steel pipes, it is appropriate that all tier 3 iron pipes should be prioritised on the same criterion, namely exceeding the safety thresholds. Asbestos cement behaves in a similar way to cast iron, in that it is a brittle material that tends to fail by fracture. Renewing all asbestos cement pipe above the safety threshold is an appropriate renewal policy.

For steel mains, we carried out a study on the manufacture and installation of steel mains through time. This has resulted in a proposal to prioritise mains based on pipe construction quality, which considers improvements in material quality, coating, jointing and installation (the integrity quality of steel pipes has improved through time). The lens of construction quality helps to further target the highest risk pipes within the above threshold category. These prioritisation criteria are only applied to the pipe-specific risk threshold; if the pipe is above the societal risk threshold it will be promoted for renewal.

In summary, the material-standard/age bands on which we will base prioritisation on are:

| Material band Standard/Age | Manufacture quality | Risk |
|---|---|---|
| **Pre 1957** | Largely qualitative documentation leading to wide variations in both material quality, welding and corrosion protection practices | High |
| **1957-1976** | Gradual changes of standards in materials, welding and corrosion protection to more quantitative and rigorous standards | Medium |
| **1977-present** | Fully quantitative material standards and industry internal standards in place; each phase of the gas pipe fabrication governed by internal industry standards with developed oversite standards in place | Low |

*Table 32: Prioritisation Criteria for Steel Mains*

In addition to prioritising the replacement of steel mains based on age, the role of cathodic protection should also be considered. MRPS does not take this into account but effective cathodic protection should significantly reduce the risk of pipe corrosion. As such, it is proposed that, before renewal, steel pipes with proven maintained cathodic protection will be removed from the renewal programme.

Our planning assumption is that the amount of work we will be able to defer due to cathodic protection will be near zero as the evidence bar to prove it has always been protected is high. In addition, cathodic protection is only applicable to a small length of lower pressure tier pipes (around 4% of LP steel has CP). Therefore, for the purposes of developing the plan and prioritising replacement activities, we have assumed all pipes above the safety thresholds do not have evidence of effective cathodic protection over their lifetime. Our proposal is to use any deferred length in RIIO-2 (due to the identification of maintained cathodic protection) to new assets going over the safety threshold or to address medium-risk above-threshold pipe.

**Phasing of Safety Work**

In the proposed plan we have included an element of phasing for the safety driven work. The profile we have planned on is to allow us to renew the highest value and most difficult to deliver assets early in the programme. There are a number of befits to this approach:

- By tackling a lower volume of more difficult work early in RIIO-2, we can develop resources who have the skills to deliver steel and larger diameter replacement, helping us deliver greater lengths later in the period.
- Delivering a larger programme in the last year of RIIO-2 allows us to transition to a high start year for RIIO-3 which will enable us to deliver a tapered programme for the last six years of the IMRRP programme.

## 10.7. Business Case Outline and Discussion

As set out above, we have an absolute duty to keep customers safe. There is evidence that assets outside the scope of the IMRRP now pose a level of risk which is comparable or greater than those in scope of the IMRRP.

As discussed in section 5.1 customers want a safe and reliable network. Customers do not distinguish between an iron and a steel, a tier 1 or a tier 2 or 3 main when it comes to keeping them safe. We are therefore proposing to extend the risk safety approach we have in RIIO-1 for tier 1 and 2 iron mains to start to cover all distribution mains.

Our aim in developing the RIIO-2 plan is to keep customers safe.

### 10.7.1. Key Business Case Drivers Description

**Mandatory T2a Iron Mains**

Applying risk thresholds as described to the draft MRPS risk scores of the tier 2 iron population identifies 37km of tier 2a safety mains above the risk threshold across our four networks that need to be replaced in RIIO-2. These assets where not above threshold using the RIIO-1 MRPS calculation.

All pipes identified for remediation will be physically decommissioned or replaced as this is currently the only method that the HSE accepts for addressing the risk. This continues the approach taken in RIIO-1.

**Non-IMRRP Safety Mains – Identifying our absolute duty requirements**

- Iron tier 1: Of the 38km of this asset we have, 6km (15%) of these non-IMRRP tier 1 iron mains are above the calculated risk threshold. (These are classified as 2" Iron but generally when excavated tend to be 2" steel so therefore we have excluded these from our IMRRP programme as detailed in our REP/2 policy document).
- Iron tier 3: There are 1,260km of tier 3 iron mains with an MRPS risk score. From these, 37km (3%) are above the calculated risk threshold. This length includes assets which are in scope of the London Medium Pressure (LMP) major project (The 6km associated with LMP has been excluded from investment for distribution mains as it is included as part of the LMP investment, see Appendix 09.06 London Medium Pressure).
- Asbestos**:** There are 12km of asbestos mains with an MRPS risk score. From these, 1km (10%) are above the calculated risk threshold.
- Steel mains: There are 4,190km of steel mains in MRPS which have MRPS risk scores. From these, 365km (9%) are above the calculated risk threshold, accounting for 0.34 incidents per annum.

This is a material volume of complex work. As discussed above we are proposing a material-standard/age-based qualifying criterion as the basis of our safety investment case for RIIO-2 to further target safety risk within these asset groups. Additional operational interventions will monitor and manage the other pipes above the safety threshold; see the Enhanced Maintenance section below.

Applying the prioritisation criteria to the assets identified above (and removing LMP which is dealt with elsewhere see business plan Appendix 9.06 London Medium Pressure) reduces the 409km above threshold to 300km above threshold and in the steel 'high' category. The 300km (5.5% of the length in scope) **accounts for 0.34 incidents per annum or 38% of Cadent's total MRPS incident risk**. As such, the proposed approach effectively targets the highest-risk pipes: it gives a greater reduction in risk score per km replaced.

Summary: The chart below shows that most of this activity is steel in the North London network. The North West has the least amount of steel safety investment required. Various factors drive the volume of work above the threshold, including the length of the asset base, the age of the assets and the building density around the assets.

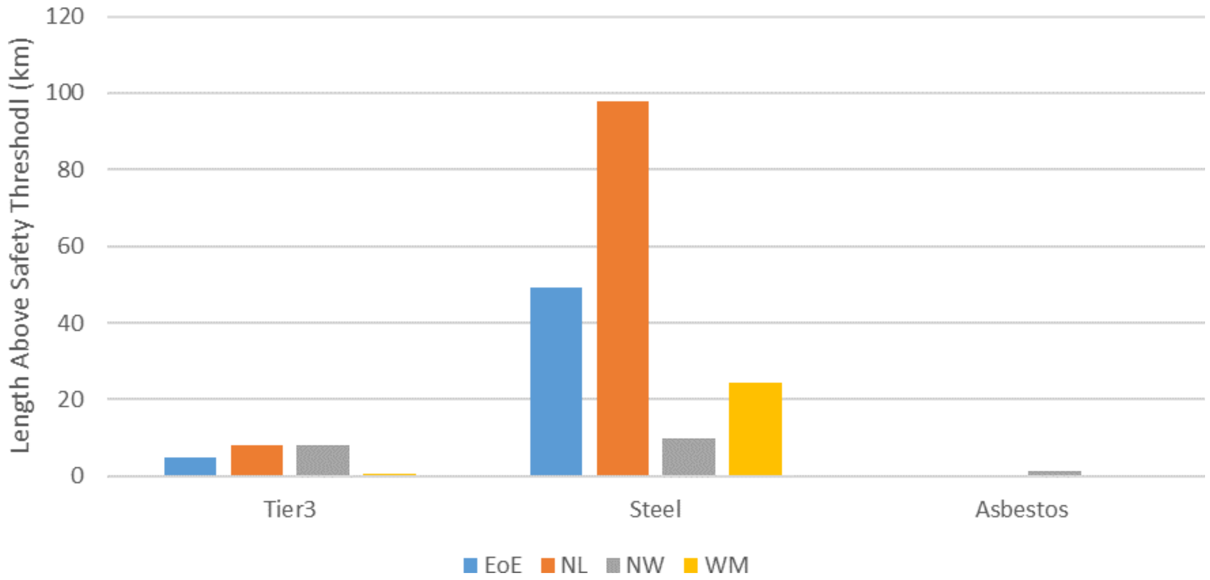



*Table 33: Length non-IMRRP above Safety Thresholds*

Further pipes scoring below the risk threshold will still be subject to intervention. Funding for additional pipe replacement will be determined via cost-benefit assessment as part of the RIIO-2 process, resulting in the removal of additional safety risk alongside other customer benefits. This is discussed further in the Enhanced Benefits section of this document.

**Dynamic growth:** As with iron pipes, steel and asbestos pipes are continually deteriorating and are subject to varying forces as the ground moves, traffic loading increases or decreases and as other utilities are installed. As with Tier 2A, we are proposing a dynamic growth element for safety pipes in RIIO-2 (see Regulatory Treatment Section 10.8.4).

The safety work outlined above effectively becomes a fixed workload that must be delivered in RIIO-2. We have used our CBA models to build efficient schemes around these fixed-safety pipes where there are opportunities to do so, allowing additional customer benefits to be achieved. The process for doing this is outlined in the Enhanced Benefits section of this document.

## Enhanced Maintenance

During RIIO-1, we have used a survey programme to proactively assess pipes that are at greater risk of failure. Our survey programmes help us comply with the PSR which emphasises that:

- Maintenance is essential to ensure that the pipeline remains in a safe condition and is fit for purpose

- Examination and monitoring of the pipeline are part of routine maintenance. The operator needs to consider both how and when the pipeline should be surveyed and examined to validate and maintain it in a safe condition.

All iron pipes at or exceeding risk thresholds currently receive an annual survey during the winter period when failures are more likely to occur due to temperature, weather and increased demand. Due to additional risks associated with ductile iron pipes, any intermediate pressure or medium pressure ductile iron pipes identified within 30 metres of a building, irrespective of their risk score, receive a survey during the winter period. All tier 3 iron mains irrespective of their risk scores are also surveyed annually due to the severity of the consequence should they fail.

The bulk of the survey programme focuses on proactive monitoring, but surveys can also be triggered when we need to increase our enhanced maintenance due to heightened risk. These surveys focus on protecting our customers. They are carried out to detect significant leakage caused by ground movement resulting from extreme weather conditions, significant ground movement or earth tremors, which may give rise to gas in buildings. These surveys are carried out on iron mains where the risk score is at or above the threshold and a vulnerable building has been identified as being within 30 meters of the pipe.

Over the past three years, the surveys that we have carried out have identified 520 leaks. The identification of leaks early (before being reported by the public) allows for repairs to be made before they can become a more serious incident. This early identification of gas escapes was highlighted by customers during research as being a top priority.

### 10.7.2. Business Case Summary

This section sets out the CBA of investment to replace mains on safety grounds. Replacement of these assets is an absolute duty under the requirements of PSR, as such an NPV-positive solution is not required.

The table shows the present value of costs for each network for the safety investment. Costs and benefits are discounted and shown in present value (PV) terms in line with Ofgem requirements and the HM Treasury Green Book. The costs for each option are based on the five years of investment in RIIO-2.

The CBA results below include all of the costs of completing the safety investment, including associated services: all costs have been included as the safety programme cannot be completed without carrying out the associated activities.

| Option No. | Option description | PV Expenditure & Costs | PV Environment | PV Safety | PV Reliability | PV Other | Total PV | NPV |
|---|---|---|---|---|---|---|---|---|
| 0 | Reactive Only | | | | | | | |
| 1 | Safety Volumes (Chosen) (RIIO-2 only) | | | | | | | |
| 2 | Safety Volumes without superstrings (RIIO-2 only) | | Redacted due to commercial sensitivity | | | | | |
| 3 | Safety Volumes without insertion benefits (RIIO-2 only) | | | | | | | |
| 4 | Safety Volumes exc. WTP (RIIO-2 only) | | | | | | | |

*Table 34: PV and NPV for Safety Scenarios*

The table below summarises the cost-benefit results for each option as a whole. This provides the NPV for the option (computed as the difference in total PV relative to the baseline) – to show which options are cost-beneficial or not. We also include the payback period, the RIIO-2 investment (replacement and refurbishment only), and the ratio of NPV to RIIO-2 investment to understand how much NPV per £ spent in RIIO-2 the options generate.

| Option No. | Option description | NPV - Relative to baseline | Cost beneficial | Payback Year | RIIO-2 spend (Replace, Refurb) | Ratio NPV to RIIO-2 replace/ refurb spend |
|---|---|---|---|---|---|---|
| 0 | **Reactive Only** | | | | | |
| 1 | **Safety Volumes (Chosen) (RIIO-2 only)** | | | | | |
| 2 | **Safety Volumes without superstrings (RIIO-2 only)** | | Redacted due to commercial sensitivity | | | |
| 3 | **Safety Volumes without insertion benefits (RIIO-2 only)** | | | | | |
| 4 | **Safety Volumes exc. WTP (RIIO-2 only)** | | | | | |

*Table 35: Cost-Benefit Summary for All Scenarios*

The options deliver benefits across the monetised risk categories: 'safety', 'environment', 'financial', and 'other'. The key societal benefits centre on reductions in safety risk.

Option 2 shows that without superstrings, investment is more expensive. The cost increase is significant and ignores cost efficiencies in delivery. It is important that we deliver our safety obligations efficiently: this is fundamental to affordable, value for money customer bills. Hence, we have discounted this option as it is inefficient, and it delivers less value per £ spent.

Option 3 shows that even without insertion benefits our investment is cost beneficial and value for money to our customers. The insertion benefit is primarily on tier 1 iron and therefore doesn't have a large effect on safety driven work. This supports our chosen option – i.e. that we will deliver value for customers even if insertion benefits do not occur.

Finally, Option 4 shows the preferred option excluding the value for interruptions. This work is safety driven and only produces a small interruptions benefit.

The table below shows the results for the regions for the preferred Option 1:

| | NPV | Cost benefit | Payback | RIIO-2 spend | Ratio NPV to RIIO-2 spend |
|---|---|---|---|---|---|
| **EoE** | | | | | |
| **NL** | | Redacted due to commercial sensitivity | | | |
| **NW** | | | | | |
| **WM** | | | | | |
| **TOTAL** | | | | | |

*Table 36: Cost-Benefit Summary for the Chosen Scenario by Region and Type*

The CBA shows that investment in the 'safety' investment is cost-beneficial overall, and particularly in the London region. Overall investment pays back by 2057. Although not cost beneficial as modelled, the North West and West Midlands investment is still valid and should be completed as this is to ensure customer safety across all networks.

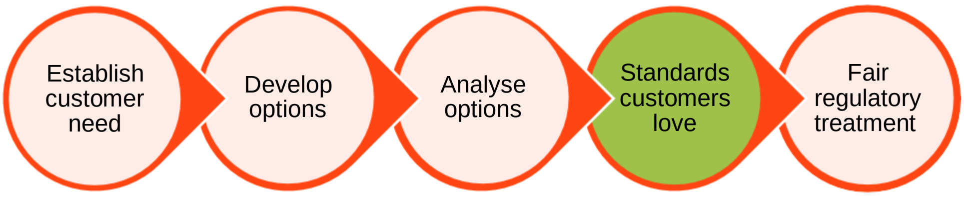
NW is not beneficial as the majority of its safety pipes are higher diameter pipe (Tier 3). Higher diameter pipes are generally more expensive to replace (due to the size of excavations required and techniques used) and offer less benefit as they do not have any connected non-PE services to be replaced (service replacement also contribute to the NPV benefit) or adjacent tier 1 mains which can be included to create longer length schemes reducing mobilisation costs.

EoE and WM both have very similar benefits with similar diameter mix, associated failures and volume of services. However, in WM it is more expensive to replace pipe than EoE due to the highly urban nature of the zone. This means while the overall benefits per meter are very similar the costs per meter are increased in WM compared to EoE.

Even though the results of the NPV across the regions are different, the strategy and approach are valid for all networks and in line with customer expectations. Replacement of mains to meet safety requirements is an absolute duty.

The PAST investment will reduce the number of potential incidents on the network, by renewing 337km of MRPS scoring mains (3% from a population of 9,900km) we can remove 38% of the total incident risk for our customers. This incident risk will increase through time and more pipes would be above the acceptable risk threshold if we were not to invest in RIIO-2. As such, we propose that the investment is in the best interests of customers despite the negative NPV in the North West and West Midlands.

## 10.8. Preferred Option Scope and Project Plan




The scenario assessment above – IMRRP tier 2a and other pipes above safety thresholds – outlines our approach to identifying the safety-mains workload for the RIIO-2 period. The following section demonstrates how the selected scenario has subsequently been translated into our workloads and output commitments within our business plan.

### 10.8.1. Preferred Option

Our preferred option is to introduce safety thresholds for all pipes to protect customers and comply with PSR, the result will be a level of risk across all assets which is in line with their expectations. To do this we will change our threshold-setting approach so that it is bespoke to each pipe and introduce a societal threshold.

### 10.8.2. Asset Health Spend Profile

Based on the MRPS safety threshold, analysis the volume of safety renewal activity by network is as follows (this table excludes associated services):

| Km Abandoned | RIIO-2 | | | | | RIIO-2 Total |
|---|---|---|---|---|---|---|
| | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | |
| EoE | 7.0 | 13.2 | 21.1 | 22.9 | 23.7 | **87.9** |
| Lon | 13.5 | 25.2 | 40.4 | 43.8 | 45.4 | **168.3** |
| NW | 2.3 | 4.3 | 6.9 | 7.5 | 7.8 | **28.7** |
| WM | 4.2 | 7.8 | 12.5 | 13.5 | 14.0 | **52.0** |
| Cadent | **27.0** | **50.5** | **80.9** | **87.6** | **91.0** | **336.9** |

*Table 37: Threshold Mains Abandon Volumes*

The investments associated with these mains are set out below. In total, we are proposing to invest *XXXX* (mains renewal spend only, services are detailed in section 12) over RIIO-2 on safety mains.

| (18/19 constant) | RIIO-2 | | | | | RIIO-2 Total |
|---|---|---|---|---|---|---|
| | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | |
| EoE | | | | | | |
| Lon | | | Redacted due to commercial sensitivity | | | |
| NW | | | | | | |
| WM | | | | | | |
| Cadent | | | | | | |

*Table 38: Threshold Mains Investment*

**<u>Enhanced Maintenance</u>**

We have clear legislative and customer drivers to enhance the leakage surveys for RIIO-2 as discussed in Section 11 of this document. Our proposal for RIIO-2 is to increase the scope of the surveys so that all assets above the risk threshold are surveyed annually. These surveys can detect small leaks that may be a precursor to a pipe's failure. To minimise the cost to the consumer, these leakage surveys will be undertaken in conjunction with existing leakage surveys where possible.

As a large percentage of the population of assets is already covered in the existing regime the increase in cost is marginal for each network. In summary:

| Network | Additional Annual Survey Cost |
|---|---|
| EoE | |
| Lon | Redacted due to commercial sensitivity |
| NW | |
| WM | |
| Cadent | |

*Table 39: Enhanced Maintenance – Additional Survey Cost*

### 10.8.3. Investment Risk

A programme risk table is included in Appendix 10.

As discussed in Section 8, we have developed robust unit costs based on our actual delivery costs in RIIO-1. Since the PAST is an asset-defined programme of works, and we know what pipes we will be replacing, we have a high confidence in the costs we are proposing for RIIO-2.

However, we are in the process of updating our MRPS system. If the results of this update are significantly different to today's understanding there may be a significant shift in the proportion of different types of work. As discussed in previous sections of this document, the characteristics of the workload, such as volume, location and type are the most critical drivers of the costs within the programme.

### 10.8.4. Regulatory Treatment

Ofgem has proposed to address this risk for Tier2a iron mains through an existing volume driver.

We are proposing to address uncertainty for both Tier 2 iron mains and PAST with volume drivers, using a unit cost approach to reflect the cost of undertaking replacement of failed pipes across our networks. The approach is already established in RIIO-1 for Tier 2a iron mains – we are proposing to extend this approach to all pipe types. For further details on this approach see Appendix 10.01 Repex - Tier 2a Iron Mains Including PAST.

# 11. Investment Methodology – Enhanced Benefits

## 11.1. Introduction

Under the regulatory framework, pipes can be put forward for remediation under cost-benefit principals ('asset management repex'). We consider cost-benefit driven activity a critical element of the overall mains renewal plan, as it allows us to deliver maximum value for our customers.

Our CBA approach for RIIO-2 is aligned with Ofgem's principles, ensuring that direct and indirect costs are captured; it is transparent in its calculations and follows cost-benefit best practice. For further detail on the CBA approach, see Appendix 4.

## 11.2. Equipment Summary

As discussed in Section 4, our distribution mains, as of RRP 2018/19, form a network of pipelines 126,000km in length. From this total length, 73% are PE assets and a further 11% are being replaced via the IMRRP programme. After factoring in the safety investment detailed above, there are around 13,500km of assets that are not subject to a proactive renewal programme. These assets, like any other distribution mains assets, deteriorate through time.

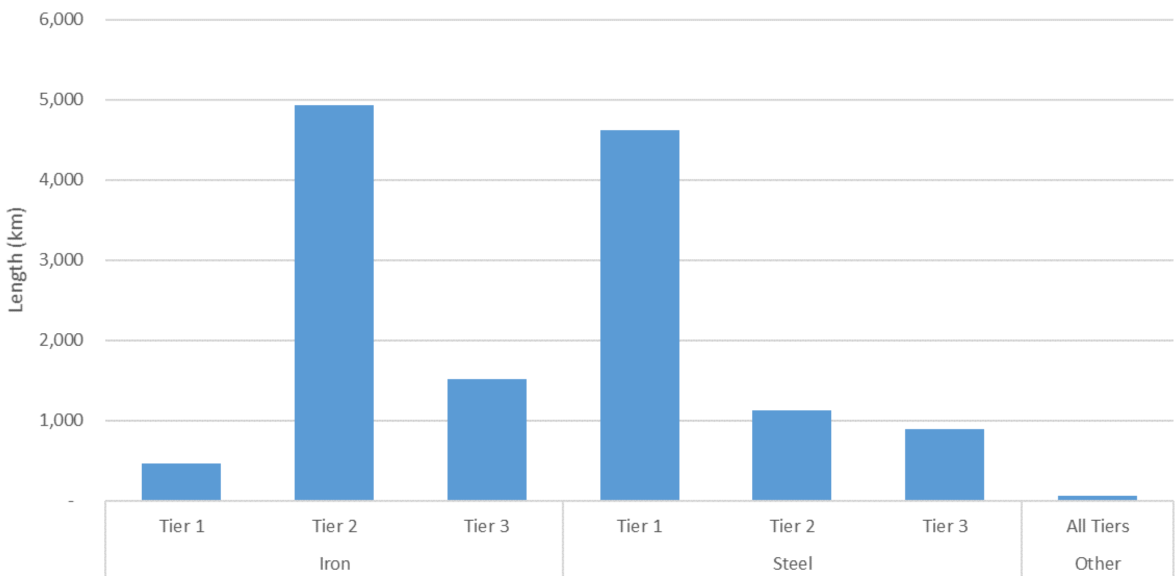
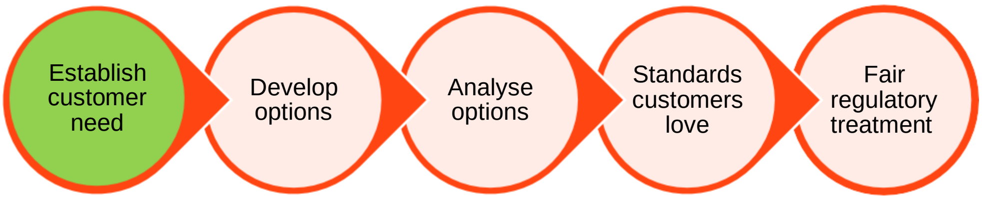



*Table 40: Length of Non-PE assets In Scope of CBA Investment*

*Picture 4: Example of a Main with Repair Clamps*

## 11.3. Problem Statement




Selecting mains on a CBA basis allows us to renew pipes that have significant operating or societal costs associated with them. Costs can be caused by a pipe experiencing numerous leaks, which may be caused by ground movement associated with traffic or unstable ground or result from poor construction when the main was originally laid many years ago. Mains that have repeated leaks can have either low or no MRPS risk scores (for example if they are more than 30m from a property) and therefore may not be selected as a safety pipe. If repairs are undertaken when problems occur, such mains can continue in operation for many years because they do not pose a high safety risk to the public.

It can be more cost-effective to replace pipes that leak repeatedly instead of continually repairing them. For example, inserting a pipe across a busy road with excavations in the footpaths on each side may be cheaper (and less disruptive to the public) than excavating in the road to fix the leak, and it will certainly be cheaper than excavating in the same road several times.

Our stakeholder engagement has clearly highlighted this as an issue, with many respondents placing emphasis on resolving escapes just once (eliminating subsequent work). Unexpected road works in busy roads, particularly if repeated, have a detrimental impact which is bringing about a policy response.

### 11.3.1. Narrative Real-Life Example of Problem


*Figure 22: Rockcliffe Drive, Bacup, RIIO-1 CBA Scheme*

This example is of a 70m-long 2” steel main located in Bacup, Lancashire.

The main leaked 12 times over its lifetime; however, four of these leaks have occurred in the last year. The majority of leaks have been from corrosion on the pipe. The recent increase in the number of failures indicates that this asset is now at the end of its serviceable life and needs replacement. As such, this asset has been promoted for replacement in RIIO-1, driven by cost-benefit.

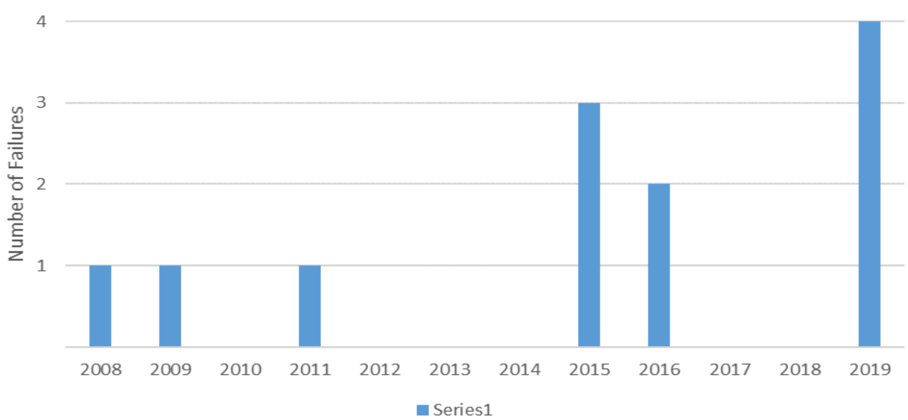



*Figure 23: Failures*

### 11.3.2. Spend Boundaries

The spend detailed in this section is for the replacement of the mains assets in scope for CBA replacement.

## 11.4. Probability of Failure

Analysis of the number of repairs, taken from core company systems, shows that the number of failures on assets that are outside of the IMRRP is increasing over time as the assets deteriorate. The number of failures shows some yearly variation, which is expected due to the impacts of weather and other external effects. The number of failures observed in RIIO-1 are shown in the chart below.

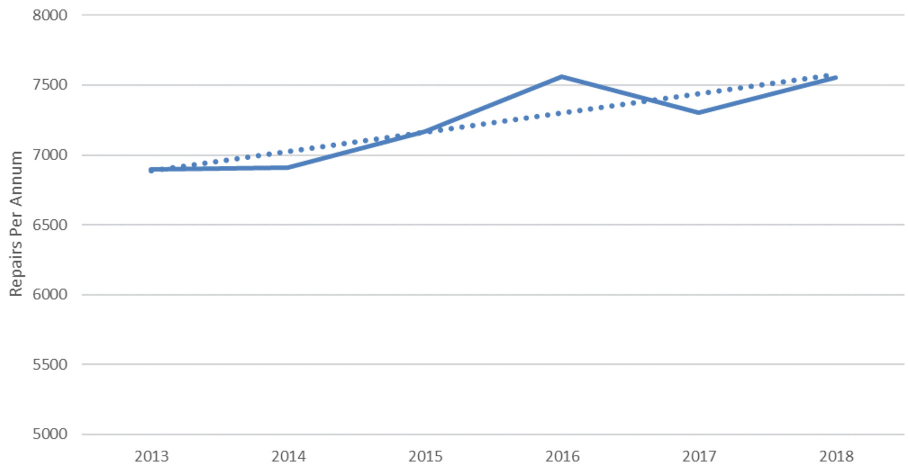



*Figure 24: Non-IMRRP Escapes Through Time*

When this is normalised by pipe length it can be seen that there is a small underlying deterioration in the number of failures from mains which are outside the scope of the IMRRP. This shows that the renewal carried out in RIIO-1 has not been enough to offset deterioration.

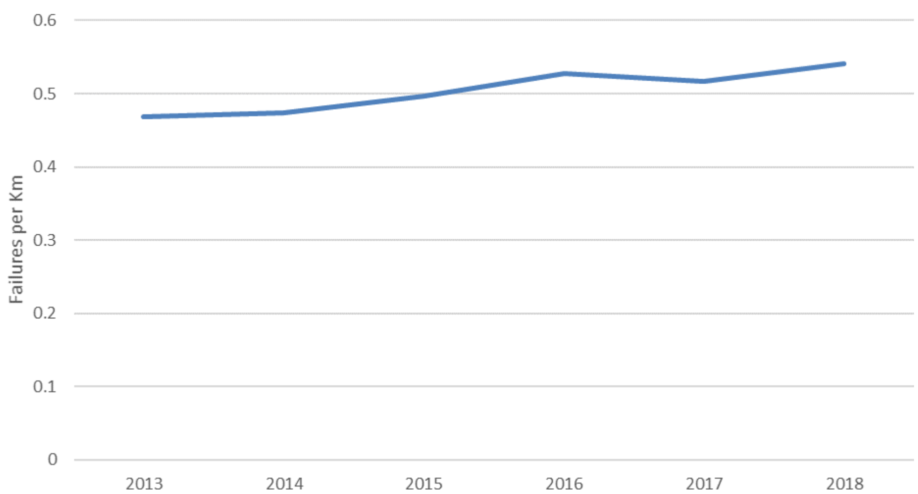



*Figure 25: Non-IMRRP Failure Rate*

## 11.4.1. Probability of Failure Data Assurance

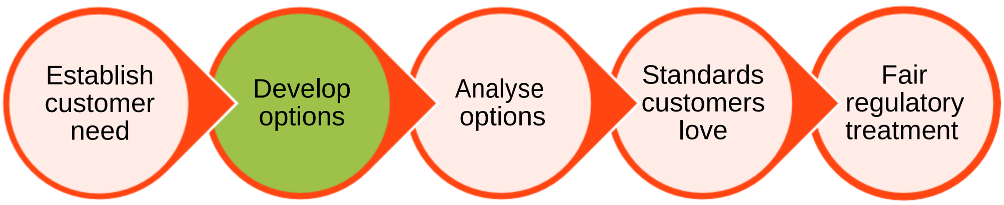
We have a high confidence in our probability-of-failure analysis as this is based on a large data set collected over many years. Our approach to forecasting deterioration is detailed in Section 7.

## 11.5. Consequence of Failure

As discussed, mains deteriorate with age which leads to the failure of the asset and an escape of gas from the network. There are multiple potential consequences of failure:

- **We must repair the asset** either using a pipe collar or enacting a short cut out and replacement. This activity costs Cadent and its customers money.
- **Gas escapes** from the asset have an environmental and a commercial impact.
- **Customers gas supplies can be interrupted** leaving them without hot water or cooking facilities. Where this happens for an extended period, alternative arrangements need to be made.
- **Customers can be inconvenienced:** if the gas escape causes an immediate health and safety concern, then customers may need to be evacuated from buildings and roads closed.

## 11.6. Options Considered




The approach for RIIO-2 uses a bottom-up assessment of all pipes in the Cadent network to assess their individual CBA attributes. At the same time, the approach aims to group CBA-positive renewal activity into larger schemes to improve efficiency. Our powerful modelling approach allows integration of work with different investment drivers to maximise benefits for our customers (further details are in Appendix 4).

To ensure it delivers the right safety outcome for customers and the public, we have fixed into the plan the safety-driven elements as discussed in the above sections. These elements of the plan become the starting points for our CBA approach; we can use our CBA models to grow efficient schemes from these fixed assets where there is opportunity to do so. Given the economies of scale that can be achieved by delivering additional length in the same geography enhanced benefit, work will often integrate with safety work or IMRRP work – the cost per metre of delivery is lower if the work is part of a larger scheme and therefore the NPV will be higher than for a pipe with similar benefits which is remote from other work.

Our approach will move us towards 'all-plastic networks' which have the potential to unlock additional benefits from improved pressure management, readiness for future gases and redeployment of work teams. However, as there remain significant volumes of non-plastic pipe in our networks, we have rejected a policy of seeking to create all-plastic networks in RIIO-2. Such a policy would have seen us replacing greater pipe lengths and investing in pipes with lower NPVs, reducing customer benefits. We would be removing pipes which still had serviceable lives (i.e. unnecessarily bringing replacement forward). We will revisit this approach for RIIO-3 once we are nearer to the tipping point of all-plastic and our network has aged another five years. As the % non-plastic in a particular network reduces the cost of converting it to all plastic reduces – as such it is easier to 'tip' the network into plastic.

The main consideration for the remainder of the plan is the volume of renewal to deliver on a CBA basis. Analysis shows that, depending on the length of time over which the model is run, many assets would be CBA positive if renewed. The benefits in the model include both 'private costs' (savings on repairs) and societal benefits (such as a reduction in greenhouse gas). It is right that our analysis focuses on both these elements rather than limiting our solution to benefits which the company can tangibly accrue.

The challenge in developing the RIIO-2 programme is to select those that give the maximum benefit when delivered alongside the IMRRP and safety-driven mains replacements.

In working groups carried out with customers, we presented a range of options with regard to the total volume of cost-beneficial work we could carry out, including no CBA investment (results are detailed in Appendix 7). The costs and potential bill impacts were presented for each option. A small percentage of customers opted for zero CBA work, with the rest split evenly between the +10km and +20km on average per year options. Given we recognise the importance of customer acceptability for our plans, we have selected to deliver the lower of the two options presented - the option of delivering 10km of CBA renewal on average per annum in each network for RIIO-2, and 20km of CBA renewal in the East of England network due to its larger mains population. This middle ground reflects the fact that the majority of customers wanted additional CBA work to be delivered, tempered by acknowledgment that some customers did not choose this option. This will be prioritised to deliver value for money for our customers, whilst ensuring bills are affordable and acceptable.

**Use of Alternative Remediation Techniques**

In RIIO-2 Cadent will continue the use of robotic techniques to remediate pipes which are in scope of CBA investment. CISBOT is an established joint remediation technique on 16” to 36” cast iron mains following successful innovation and development work completed during RIIO-1 by Cadent and other GDNs.

Stakeholder feedback for CISBOT has been strongly positive, in particular for use in super-urban environments where conventional mains replacement and the associated upheaval over extended periods are seen as an unattractive last resort by local authorities managing busy city centres. We operate some large diameter mains that deteriorate on an accelerated basis in some locations, driven by the levels of vibration caused by heavily trafficked roads and sometimes from train networks.

CISBOT remediates lead-yarn joints by injecting anaerobic sealant from inside the main. The HSE accepts the use of CISBOT as a proactive technique to address leakage risk and as a means of improving the safety of our assets. However, the technique is not permitted for the replacement of assets that are in scope due to breaching safety criteria. We are therefore including CISBOT within our plan only for use on CBA and non-safety driven Tier 3 works.

Cadent delivered 5km of work in July 2018 to in the North London network and further projects have been identified for the remaining years of RIIO-1. Additionally, SGN have used CISBOT quite extensively in the part of London they distribute gas within.

The CISBOT approach isn't necessarily a cheaper option for pipe rehabilitation. However, the technique is quicker to implement than open cut/insertion techniques and is therefore hugely welcomed by London Boroughs and Highway Authorities as a proactive approach to mitigate joint leakage in problematic areas. In some cases, local authorities have been extremely resistant to conventional replacement works in particularly sensitive areas due to the scale and duration that such works have, and we respect their concerns and their role to co-ordinate works and manage busy and economically critical city centres.

CISBOT has created an opportunity to manage the health of large diameter assets in some such locations in a manner that satisfies the concerns of local authorities. As such, CISBOT supports programme delivery of repex work by creating a much-needed additional option to balance the expectations of all stakeholders.

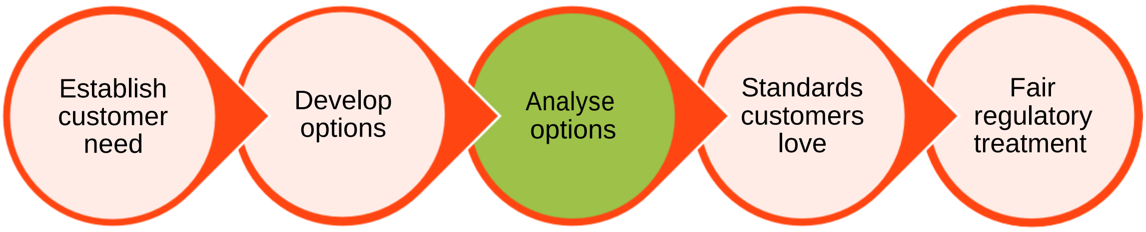
For RIIO-2 we propose to deliver 50% of our iron CBA investment using CISBOT within the qualifying diameter bands, the scope of this work have been included in the robotics intervention section of the BPDTs. Through stakeholder engagement about our investment plans we will target CISBOT to areas that deliver the most benefit to customers and communities, and we expect that the application of this relatively new innovation will evolve over the RIIO-2 period across all UK GDNs.

**Phasing of CBA Work**

In the proposed plan we have included an element of phasing for the enhanced benefit driven work. As per PAST investment, the profile we have planned on is to allow us to renew the highest value and most difficult to deliver assets early in the programme. There are a number of befits to this approach:

- By tacking a lower volume of more difficult work early in RIIO-2, we can develop resources who have the skills to deliver steel and larger diameter replacement, helping us deliver greater lengths later in the period.
- Delivering a larger programme in the last year of RIIO-2 allows us to transition to a high start year for RIIO-3 which will enable us to deliver a tapered programme for the last six years of the IMRRP programme.

## 11.7. Business Case Outline and Discussion




### 11.7.1. Key Business Case Drivers Description

As with the prioritisation of the IMRRP, there are multiple ways that the CBA activity can be prioritised and delivered. Each of the approaches will trade-off outputs which include risk to the safety of mains, efficiency of delivery, the benefit of repairs, leakage, interruptions and customer experience.

To be consistent with customers' requirements and the IMRRP, we have developed a balanced plan which considers the benefit to the environment, repairs, safety and customer performance equally.

### 11.7.2. Business Case Summary

This section sets out the CBA of investment to replace mains as part of the Enhanced Benefits investments. Our approach to assessing CBA is to understand what additional cost benefit investment there is in our mains once we have identified our safety and IMRRP mandated investment. This means we optimise and assess our mains programme collectively.

Investment has been capped at 10km a year in line with customers' views: In working groups with customers we presented a range of options with regards to the total volume of cost beneficial work we could carry out, including no CBA investment. Given it is essential that we have high levels of acceptability for our plans, we have selected to deliver modest levels of investment associated with the 10km lower length (20km of CBA renewal in the East of England network due to its larger mains population).

In practice, we have considered all of our mains in AIM collectively. We have set constraints to ensure mandated investment and no more than 10km of CBA work is picked; the objective function to minimise the whole life costs of mains subject to meeting these dual constraints. This means we will meet our mandated obligations at least cost; and we will select any additional cost beneficial investment within the length constraint.

This approach to assessing our mains programme ensures that we do not double count or miss valuable investment – and ensures we get the biggest return for our customers on investment made, whilst being affordable to our customers.

Overall, our plan represents the optimal mix of mandatory, safety and cost-benefit driven work.

The table shows the present value of costs for each option. This shows five years of investment over RIIO-2, unless stated otherwise. The table shows the discounted present value of costs for each option to 2071.

| Option No. | Option description | PV Expenditure & Costs | PV Environment | PV Safety | PV Reliability | PV Other | Total PV | NPV |
|---|---|---|---|---|---|---|---|---|
| 0 | Reactive Only | | | | | | | |
| 1 | Max Benefit 10km a year (Chosen) (RIIO-2 Only) | | | | | | | |
| 2 | Max Benefit 10km a year without superstrings (RIIO-2 Only) | | Redacted due to commercial sensitivity | | | | | |
| 3 | Max Benefit 10km a year without insertion benefits (RIIO-2 Only) | | | | | | | |
| 4 | Max Benefit 10km a year (RIIO-2 + RIIO-3) | | | | | | | |
| 5 | Max Benefit 10km a year (RIIO-2 Only) exc. WTP | | | | | | | |

Table 41: PV and NPV for scenarios

The options deliver benefits across the monetised risk categories: 'safety', 'environment', 'financial', and 'other'. The key societal benefits centre on reductions in safety and environmental risk.

The table below summarises the cost-benefit results for each option. This provides the NPV for the option (computed as the difference in total PV relative to the baseline) – to show which options are cost-beneficial or not. We also include the payback period, the RIIO-2 (replacement and refurbishment only), and the ratio of NPV to RIIO-2 to understand how much NPV per £ spent in RIIO-2 the options generate.

| Option No. | Option description | NPV – Relative to baseline | Cost beneficial | Payback Year | RIIO-2 spend (Replace, Refurb) | Ratio NPV to RIIO-2 replace/ refurb spend | RIIO-3 spend (Replace, Refurb) | Ratio NPV to RIIO-2 and RIIO-3 (Replace, Refurb) |
|---|---|---|---|---|---|---|---|---|
| 0 | Reactive Only | | | | | | | |
| 1 | Max Benefit 10km a year (Chosen) (RIIO-2 Only) | | | | | | | |
| 2 | Max Benefit 10km a year without superstrings (RIIO-2 Only) | | Redacted due to commercial sensitivity | | | | | |
| 3 | Max Benefit 10km a year without insertion benefits (RIIO-2 Only) | | | | | | | |
| 4 | Max Benefit 10km a year (RIIO-2 + RIIO-3) | | | | | | | |
| 5 | Max Benefit 10km a year (RIIO-2 Only) exc. WTP | | | | | | | |

*Table 42: Cost-Benefit Summary for All Scenarios*

Our chosen investment, Option 1, provides the additional cost beneficial investment over and above our mandated programme of works for these assets. Our preferred option is very cost beneficial, delivering benefits around safety, the environment and interruptions.

With our chosen option, and indeed most of the other options considered, the payback period is very short. We compute the payback period to be the point at which the stream of discounted benefits from investment exceeds the stream of discounted investment costs. The capitalisation rate of 100% spreads the cost of investment – meaning that the benefits to our customers from investment exceed the cost to customer's bills from the start of the programme. We have tested the impact of changing the capitalisation rate – for example, changing this to the company wide capitalisation rate for RIIO2 (27.7%) increases the payback to 2034; and changing it to 0% increases the payback to 2035. From this we can conclude that our chosen CBA work is incredibly good value for our customers, and we consider the risk of asset stranding to be low (see Appendix 4 for a further discussion, also section 9.00 for further sensitivity analysis).

Option 2 demonstrates that without superstrings investment is more expensive and has the longest payback period of all the options. The cost increase is significant and ignores cost efficiencies in delivery. This option is not our preferred option as it delivers less value per £ spent.

Option 3 shows that even without insertion benefits our investment is cost beneficial and value for money to our customers. This confirms our chosen option is in line with customers' views.

Option 4 shows that there is investment in RIIO-2 and RIIO-3 that is cost beneficial. It also shows that we have sought to identify those investments with the lowest unit costs first and foremost, and therefore the greatest benefit to customers in RIIO-2.

Finally, Option 5 is for comparative purposes only and shows the preferred option excluding the value for interruptions. This is used to show our preferred plan is very cost beneficial excluding the benefits from avoiding customer interruptions.

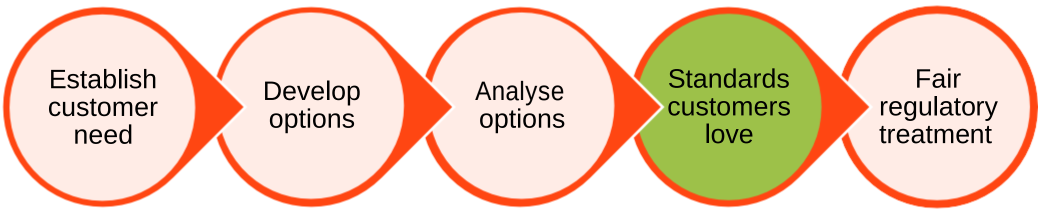
The table below shows the results for the regions for the preferred Option 1:

| | NPV | Cost-benefit | Payback | RIIO-2 spend | Ratio NPV to RIIO-2 spend |
|---|---|---|---|---|---|
| EoE | | | | | |
| NL | | Redacted due to commercial sensitivity | | | |
| NW | | | | | |
| WM | | | | | |
| TOTAL | | | | | |

*Table 43: Cost-Benefit Summary for the Chosen Scenario by Region and Type*

CBA shows that investment in the Enhanced Benefits investment is cost-beneficial in all networks. In all four networks the payback period is short, with the benefits to customer exceeding the costs to customers (i.e. the impact on the customer bill) from the first year of the investment plan in London and West Midlands overall; and a slightly longer payback period in East of England and the North West.

## 11.8. Preferred Option Scope and Project Plan




The scenario assessment above outlines our approach to identifying the CBA workload for the RIIO-2 period. The following section demonstrates how the selected scenario has subsequently been translated into our workloads and output commitments within our business plan.

### 11.8.1. Preferred Option

Our preferred option is to deliver 10km (20km for EoE) of CBA renewal per network per year as per customers' expectations to target the highest-benefit assets on the basis of cost and the community. The result will be environmental and customer benefits as well as a reduction in the number of failures.

### 11.8.2. Asset Health Spend Profile

The following section demonstrates how the selected scenario has subsequently been translated into our workloads and output commitments within our business plan.

The proposed CBA workload is as detailed in the table below:

| Km Abandoned | 21/22 | 22/23 | RIIO-2 23/24 | 24/25 | 25/26 | RIIO-2 Total |
|---|---|---|---|---|---|---|
| EoE | 8.0 | 15.0 | 24.0 | 26.0 | 27.0 | **100.0** |
| Lon | 4.0 | 7.5 | 12.0 | 13.0 | 13.5 | **50.0** |
| NW | 4.0 | 7.5 | 12.0 | 13.0 | 13.5 | **50.0** |
| WM | 4.0 | 7.5 | 12.0 | 13.0 | 13.5 | **50.0** |
| Cadent | **20.0** | **37.5** | **60.0** | **65.0** | **67.5** | **250.0** |

*Table 44: Enhanced Benefit Mains Abandon Volumes*

The investments associated with these mains are set out below. In total, we are proposing to invest *XXXX* (mains renewal spend only, services are detailed in section 12) over RIIO-2.

| (18/19 constant) | 21/22 | 22/23 | RIIO-2 23/24 | 24/25 | 25/26 | RIIO-2 Total |
|---|---|---|---|---|---|---|
| EoE | | | | | | |
| Lon | | | | | | |
| NW | | | | | | |
| WM | | | | | | |
| Cadent | | | | | | |

*Table 45: Enhanced Benefit Mains Investment*

## 11.8.3. Investment Risk

A programme risk table is included in Appendix 10.

## 11.8.4. Regulatory Treatment

This work will be reported through the NARMs methodology as Asset management repex activities. This approach is in line with other investment which covers a range of interventions which do not fall under the mandatory repex category above.

# 12. Investment Methodology – Service Replacement

## 12.1. Introduction

As a public gas transporter, we have a duty to minimise the risk our operations have on the general public and for RIIO-2, therefore, we intend to mitigate against the risk of an incident occurring by replacing all steel services when encountered during routine operations – following a Public Reported Escape (PRE) or in association with mains replacement activity – together with some selective condition renewals targeted at areas where corrosion failures are observed to be highest.

This section covers service renewal in association with mains replacement only. For other service replacement activities see Appendix 09.03 Services Not Associated with Mains Replacement.

## 12.2. Equipment Summary

We have over 11 million service pipes supplying consumers in domestic, industrial, commercial and multiple occupancy buildings (MOBs) direct from the network. The service pipe is the last part of the network connecting distribution mains to customers' meters. The following table shows the breakdown by network:

| '000s | EoE | Lon | NW | WM |
|---|---|---|---|---|
| Number of services | 4,024 | 2,275 | 2,693 | 1,965 |
| MOBs | 17 | 65 | 16 | 10 |
| Cadent Total | 4,041 | 2,340 | 2,709 | 1,975 |

*Table 46: Service Asset Base by Customer Type per RRP 2018-19*

Services were laid almost entirely in steel until the introduction of PE in the mid-1970s. Services are now laid exclusively in PE, except where the pipe is to be above ground or there are other specific engineering challenges.

Most of our service population is PE, although some of the earliest types of PE services were laid with a steel house entry (referred to as a 'steel tail'). This occurred from the mid-1970s to the early 1980s when house-entry fittings allowing PE up to the ECV (Emergency Control Valve) were not available.

The table below shows the approximate distribution of the 11 million services by material type:

| '000's | EoE | Lon | NW | WM |
|---|---|---|---|---|
| PE | 3,603 | 2,018 | 2,364 | 1,690 |
| Steel | 392 | 246 | 308 | 263 |
| Mixed | 29 | 11 | 20 | 12 |

*Table 47: Service Asset Base by Material Type per RRP 2018-19*

Services of all material types will typically be of ¾" to 1½" internal diameter, although some industrial and commercial services are larger. These larger services (2" diameter and above) are selected for replacement in accordance with mains replacement criteria.

*Picture 5: A Steel Service on an Iron Main*

## 12.3. Problem Statement


To mitigate against the ongoing risk of service failure due to corrosion, we currently replace all steel service pipes entirely with PE if they are found during routine operations. All steel services suffer from ongoing corrosion and will require replacement at some point in the future. It is much more efficient to undertake replacement at marginal cost when the pipe is exposed during routine operations.

Customers prefer reduced disruption and being able to complete service replacement at the same time as mains replacement removes the need for subsequent visits.

### 12.3.1. Narrative Real-Life Example of Problem

Assets within 30 metres of a build have the potential to cause a major incident, leading to serious injury or loss of life. See Section 9.3.1. for a case study of an incident which occurred in 2010, this occurred on a 9” iron main (gas escape from a service has caused similar incidents).

### 12.3.2. Spend Boundaries

The spend detailed in this section is for the replacement of the services associated with all mains replacement.

## 12.4. Probability of Failure

Analysis of the number of relay after escapes taken from RRP data shows that the number of service failures result in a new asset being installed is moderately decreasing over time as the mains renewal programme relays the associated steel services. The number of failures shows some yearly variation: this is expected due to the impact of weather and other external effects.

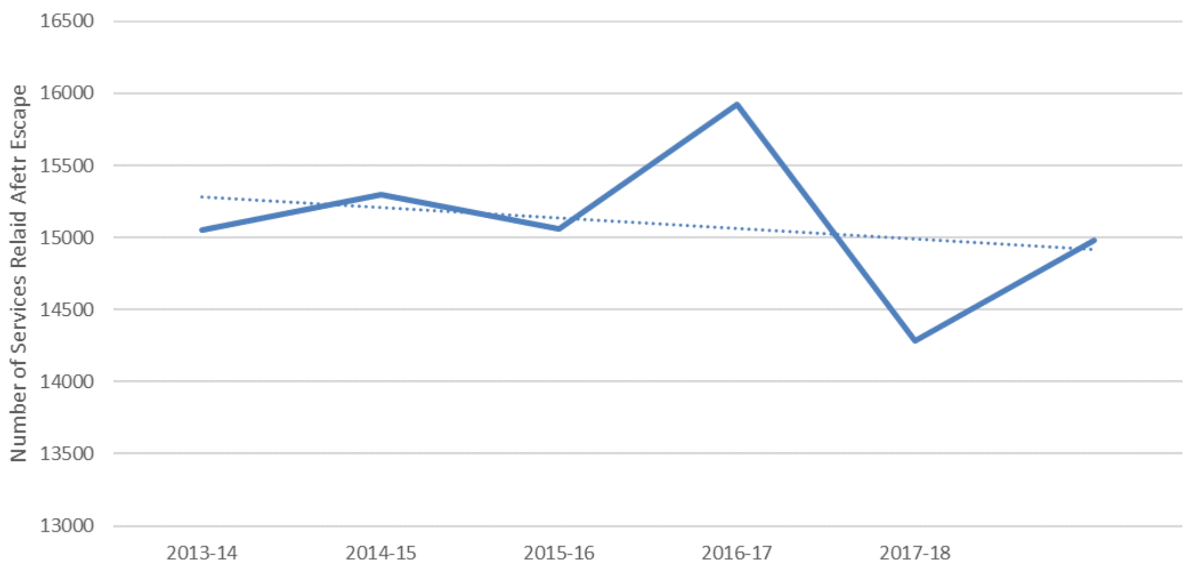



*Figure 26: Iron Main Gas Escapes Through Time*

### 12.4.1. Probability of Failure Data Assurance

We have a high confidence in our probability-of-failure analysis as this is based on a large data set collected over many years. Our approach to forecasting deterioration is detailed in Section 7.

## 12.5. Consequence of Failure

The aim of mains renewal is to ultimately to reduce the occurrence of asset failures and building explosions due to failed iron distribution mains. As per mains, explosions are caused by gas tracking into properties, which then builds up and ignites.

The trend of incidents (property explosions) caused by services for the past 28 years is shown in the figure below. See section 9.3.1. for a real-life example of an incident caused by a gas explosion. The number of incidents that occurred due to the failure of a distribution main each year is shown in blue. A 5-year rolling average is shown in orange.

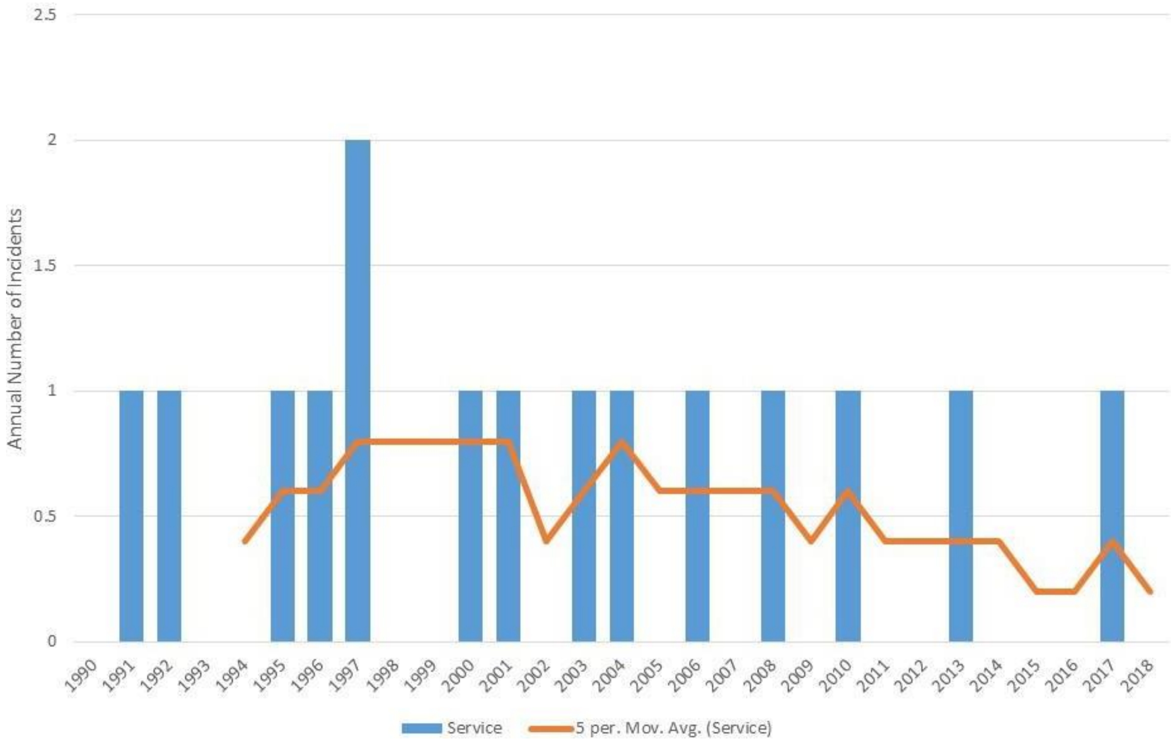
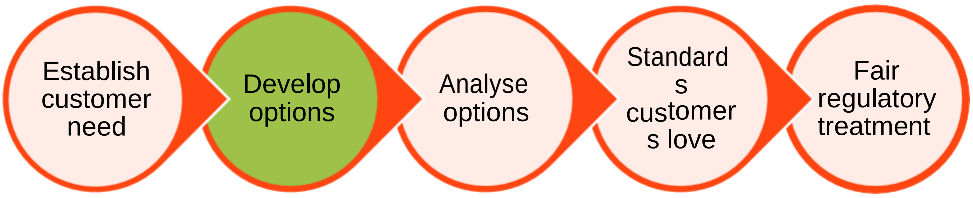



*Figure 27: Number of Incidents Caused by Services Nationally*

## 12.6. Options Considered




When we intervene to replace a main, we will also, as a matter of course, replace the associated service pipe where it is metallic. This intervention is cost-effective – the team is already on site and an excavation has already been completed. In addition, the replacement of the service creates safety and performance benefits for the customer.

There are four categories of steel service pipe replacement:

| Category | | Description |
|---|---|---|
| 1 | In association with mains replacement | The renewal of non-PE service pipes at the same time as the renewal of the parent main |
| 2 | Selective renewals | Targeted programmes of steel service replacement. This is generally done on a 'hot spot' basis where the services are attached to PE mains |
| 3 | Following a Public Reported Escape (PRE) | The renewal of service pipes when they cause a gas escape. |
| 4 | Alterations/ Other | Generally associated with meter alterations where a new service pipe is required due to a location change. Or where services are replaced to improve pressure. |

*Figure 28: Service Investment Drivers*

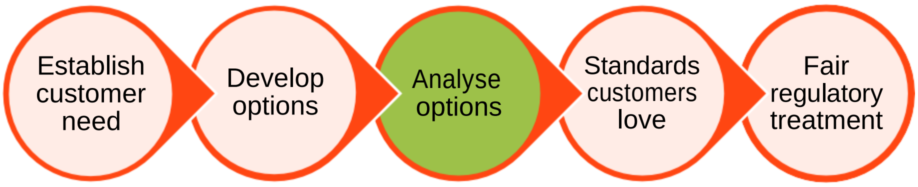
Mains replacement activity interrupts the supply of gas to all properties supplied from the pipe scheduled to be abandoned. As this requires the physical isolation of a service at a point where it connects to the main, replacement of a disconnected steel service pipe, usually by insertion with a new PE service pipe at the same time as the main is replaced, can be done at a marginal incremental cost.

In addition, while steel services could be transferred to the new PE main, the physical manipulation of a steel service can affect its integrity: for example, damage to the wrapping would result in accelerated corrosion. Only PE services are therefore transferred onto any new PE main. The HSE also expects that steel services be replaced at the same time as a metallic main is replaced.

Replacing the service in this manner also delivers benefits to the consumer, as their supply of gas will only be disconnected on one occasion, minimising personal disruptions such as having to take time off work.

As part of our CBA modelling, the costs of service transfers and relays have been captured and included in the analysis. The CBA model understands the additional costs of service-pipe replacement associated work with each main, as well as the benefits those replacements can bring and is able to factor this into the overall calculation.

## 12.7. Business Case Outline and Discussion



### 12.7.1. Key Business Case Drivers Description

As the CBA modelling is carried out on a bottom-up, pipe-by-pipe basis, any individual pipe's service investments have been calculated. This is based on a geospatial analysis of the meter points and connecting them to appropriate mains.

The analysis shows that service densities on replaced mains are expected to decrease in the East of England network by 7% as we move towards the more rural East Anglia part of the network. However, we are expecting service densities in North London to increase by 23% as we tackle areas with higher density services. We are not expecting to see a change in service density in either the North West or West Midland networks.

### 12.7.2. Business Case Summary

The cost and benefits have been included in the three mains renewal sections above, therefore there is no standalone business case summary.

## 12.8. Preferred Option Scope and Project Plan


### 12.8.1. Preferred Option

We will continue to replace steel services as part of our routine mains replacement operations. This will mitigate from having to carry out a more expensive renewal of services at a later point.

### 12.8.2. Asset Health Spend Profile

Based on the service densities in the CBA model and the mains renewal workload detailed in the above sections, we predict that we will replace 538k services during RIIO-2 with the transfer of 319k existing PE services onto the new PE main.

| | RIIO-1 | | | RIIO-2 | | | | | RIIO-2 Total |
|---|---|---|---|---|---|---|---|---|---|
| **# Relayed** | **18/19** | **19/20** | **20/21** | **21/22** | **22/23** | **23/24** | **24/25** | **25/26** | |
| **EoE** | 24,946 | 27,284 | 26,680 | 23,674 | 23,856 | 24,090 | 24,142 | 24,168 | **119,931** |
| **NL** | 23,009 | 26,280 | 25,457 | 32,541 | 33,298 | 34,271 | 34,488 | 34,596 | **169,194** |
| **NW** | 22,283 | 33,035 | 35,639 | 26,940 | 27,155 | 27,432 | 27,493 | 27,524 | **136,545** |
| **WM** | 18,678 | 25,432 | 25,029 | 21,912 | 22,282 | 22,757 | 22,863 | 22,916 | **112,730** |
| **Cadent** | **88,916** | **112,031** | **112,804** | **105,068** | **106,592** | **108,551** | **108,986** | **109,204** | **538,400** |

*Table 48: Service Relay Volumes*

| # Transfer | RIIO-1 18/19 | RIIO-1 19/20 | RIIO-1 20/21 | RIIO-2 21/22 | RIIO-2 22/23 | RIIO-2 23/24 | RIIO-2 24/25 | RIIO-2 25/26 | RIIO-2 Total |
|---|---|---|---|---|---|---|---|---|---|
| EoE | 26,539 | 29,027 | 28,385 | 26,012 | 26,220 | 26,487 | 26,547 | 26,576 | **131,843** |
| NL | 8,085 | 9,227 | 8,938 | 11,109 | 11,367 | 11,699 | 11,773 | 11,810 | **57,758** |
| NW | 11,961 | 17,639 | 19,028 | 13,882 | 14,027 | 14,213 | 14,255 | 14,276 | **70,652** |
| WM | 9,184 | 12,531 | 12,333 | 11,351 | 11,539 | 11,781 | 11,835 | 11,862 | **58,369** |
| Cadent | **55,769** | **68,424** | **68,685** | **62,354** | **63,153** | **64,181** | **64,410** | **64,524** | **318,622** |

*Table 49: Service Relay Volumes*

In total, we are proposing to invest *XXXX* over RIIO-2.

| Spend | RIIO-1 18/19 | RIIO-1 19/20 | RIIO-1 20/21 | RIIO-2 21/22 | RIIO-2 22/23 | RIIO-2 23/24 | RIIO-2 24/25 | RIIO-2 25/26 | RIIO-2 Total |
|---|---|---|---|---|---|---|---|---|---|
| Relay | | | Redacted due to commercial sensitivity | | | | | | |
| Transfer | | | | | | | | | |
| Cadent | | | | | | | | | |

*Table 50: Service Investment*

## 12.8.3. Investment Risk

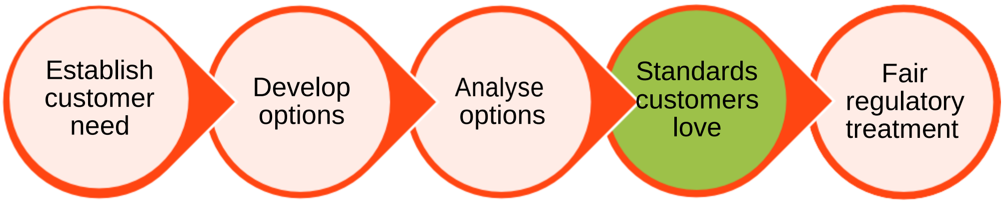
Please see Appendix 10.

## 12.8.4. Regulatory Treatment

The outputs we proposed for repex were defined in terms of volume (i.e. number of replacements). Given the uncertainty around workload volumes for non-PE service replacements, Ofgem think there is financial risk in setting a fixed target for RIIO-GD2. In addition, Ofgem consider that before setting the approach to the services output, it is important that they have an idea of their approach to services cost assessment. We will continue to work with Ofgem on the regulatory treatment options for services.

It is Cadent's view that replacement of non-PE services would be included as part of the Network Asset Risk Metric (NARM) which would be the main mechanism for ensuring the efficient delivery of non-PE service replacements over RIIO-GD2.

# 13. Standards our Customers will Love




The elements described above come together to deliver a package of work which will secure significant benefits for our customers.

Internally we tested over 20 options across the three areas of investment using valuations of carbon, safety and repair costs to explore how we can best develop a programme of work in line with customer input. From this broad list, we selected seven options to test in more detailed sessions with customers during the summer (see Appendix 7). These workshops have allowed us to refine our proposals and develop the options which will be put forward in the acceptability testing.

We tested our plan with customers and stakeholders to assess the acceptability of our overall business plan in terms of its content/quality and its affordability. As part of the Traverse quantitative acceptability testing of domestic customers (October 2019), 83% of those surveyed found the resilient network section of the plan acceptable, and only 1% found it unacceptable. Generally, participants agreed with all elements of the plan to deliver a resilient network.

One customer in our Liverpool fuel poor focus group said that ‘this is a beautiful plan’.

We will deliver the right balance of safety, reliability, environmental and cost benefits.

# 14. Regulatory Treatment Summary


We agree with Ofgem's view that the use of Price Control Deliverables (PCD) combined with uncertainty mechanisms is appropriate for the delivery of repex workloads in RIIO-2.

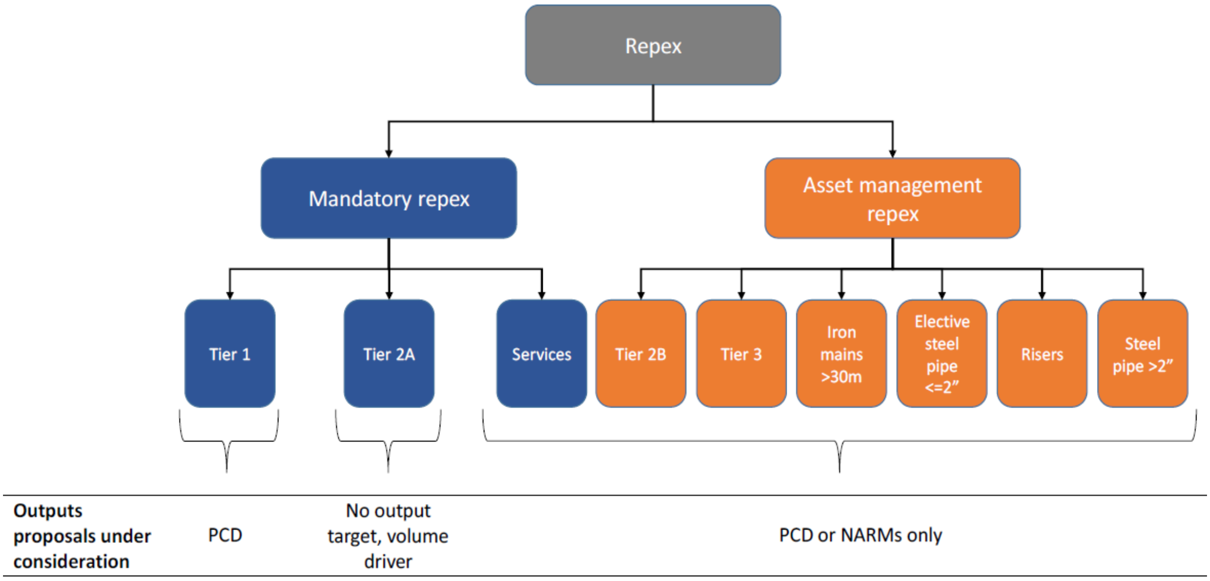



*Table 51: Ofgem's Repex Classification*

Our plan is focused on keeping our customers safe. A key of this is tracking the performance of our distribution network with regards to the risk posed by individual lengths of pipe through time. To do this, we use the Mains Risk Prioritisation System (MRPS).

As discussed in section 10, if a pipelines score increases above a fixed safety threshold - as a result of increased failures or changes which mean that gas is more likely to enter homes – then we will act to replace that pipe. This ensures we keep our customers safe and comply with the Pipeline Safety Regulations (1996).

Ofgem has proposed to address this risk for Tier2a iron mains through an existing volume driver. We propose to expand this, with an additional volume driver to address other pipes above a safety threshold.

The mandatory repex category, as illustrated in the Ofgem diagram above, is only focused on the current HSE enforcement policy and does not account for other mandatory safety work driven by Pipeline Safety Regulations (1996).

Customers have been clear that they expect us to keep them safe. The HSE is supportive of the proposed evolution in approach we have outlined in this plan. The legal requirement is absolute. We therefore propose that an additional blue box should be added to cover 'other mandated repex' like tier 2a and other pipes above safety thresholds.

A transparent and fair regulatory treatment would have the following characteristics:

| Category | Description |
|---|---|
| **Tier 1 (IMRRP)** | Ofgem has proposed to address this risk for Tier2a iron mains through an existing volume driver.<br><br>We are proposing to address uncertainty for both Tier 2 iron mains and PAST with volume drivers, using a unit cost approach to reflect the cost of undertaking replacement of failed pipes across our networks. The approach is already established in RIIO-1 for Tier 2a iron mains – we are proposing to extend this approach to all pipe types. For further details on this approach see Appendix 10.01 . |
| **Tier 2a** | As in RIIO-1, a volume driver to fund mains replacement for tier 2a Mains and ductile iron mains within 30 metres of a building. Volumes of tier 2a work are uncertain due to risk scores on individual mains changing over time. |
| **Pipes Above Safety Threhsold** | We are proposing to extend the uncertainty mechanism for Tier 2 iron mains to cover PAST with volume drivers, using a unit cost approach to reflect the cost of undertaking replacement of failed pipes across our networks. The approach is already established in RIIO-1 for Tier 2a iron mains – we are proposing to extend this approach to all pipe types. For further details on this approach see business plan Appendix 10.01. |
| **Asset Management Repex – Enhanced Maintenance** | No set output targets for asset management repex activities as they are covered in the NARMs targets. Not having a target would allow flexibility to manage our assets as we deem efficient during the price control period, adapting to any changes over time. |

Table 52: Regulatory Treatment Proposals

# 15. Assurance

Cadent has designed an assurance process to provide high level assurance to our Board. This approach is set out in more detail in Chapter 12 Assurance and Appendix 12.01 Our Assurance Framework & Evidence.

Within this section we have focussed on expanding on some of the key assurance activities specifically related to the Engineering Investment Decision Packs (IDPs), which comprise the Engineering Justification Papers, Cost Benefit Analysis and the related NARMs and BPDTs associated with these IDPs.

In producing our IDPs we have followed a number of key steps to ensure the investment cases are founded on robust data and were developed in compliance with our ISO55001 accredited asset management process. Our asset management process also delivers compliance with our legal and regulatory requirements as well as delivering value for customers. We have also implemented a strict review and governance process to ensure that subject matter experts with the relevant expertise develop the plans, which have been separately and independently reviewed by regulatory economic consultants and proof-read by an external advisor as well as being reviewed by, our senior leadership team and Board, and; challenged and supported by the Customer Engagement Groups (CEG) and Finance and Investment Working Group (FIWG). The key steps are set out below:

- **Data provision and assurance**: We have worked closely with data owners and SMEs from across the business to provide data and engineering expertise to inform these investment cases. This has been assured through the application of the Data Assurance Guidelines (DAG) process to CBAs, BPDTs and CBA models.
- **Comprehensive methodology documents**: We have documented our overall process for developing our capex and repex plans which have been reviewed by our second line assurance providers, PwC. We have also produced comprehensive internal methodology documents to record the development of our investment plans which has been reviewed and approved by key SMEs within the business and have been subject to external assurance by PwC, Costain and Lloyds.
- **Ongoing engagement with Cadent senior leadership**: Our asset strategy sub-group (ASSG), attended by our senior leadership team and directors, considered investment proposal outputs for compliance with strategy and that they were fit for purpose. These included a review and sign-off phase.
- **Periodic engagement with dedicated sub-groups**: We have undertaken planned engagement with our CEG, specifically focussed on the FIWG.
- **Focussed engagement with our Board**: Our Board have been intimately involved in the development of our plan. The outputs from work at the CEG and Asset Strategy Sub-group fed into sessions with both our Executive Team and Board, that allowed extensive challenge and review.

In accordance with our assurance process, in areas of particular complexity we have employed specialist external third-party suppliers to assure the work we've undertaken. External assurance has been completed in the following areas:

| Area of Assurance | Provider of assurance | Approach |
|---|---|---|
| **Asset management approach** | Lloyds Register | Assessment of our methodology; specific deep dives into specific investment line. |
| **Costing Methodology** | Costain | Review of overall approach and detailed review on specific investment lines. |
| **Economic modelling**<br>**(CBA and use of WTP)** | NERA | Assessment of our approach; deep dives into specific investment line. (6 CBA models) |
| **BPDT production and methodology** | KPMG | KPMG provided a review of specific inputs files that feed data to BPDTs covering the structure of the files, linearity, hard coded inputs in these files, and a detailed review of unique formulae where required. |
| **NARMs modelling**<br>**(population of tables)** | ICS Consulting Ltd | Testing of the models built for NARMs reporting against the industry published NOMS methodology. |

Table 53: Assurance completed

This specialist assurance began in July and was concluded in December where the specialist providers were able to provide assurance that recommendations had been successfully implemented.

The following table summarises the Assurance Provider's actual findings as stated in their final reports or supporting commentary.

| Assurance Provider | Summary of Findings |
|---|---|
| NERA | *"We concluded that Cadent's CBA modelling had been performed to a high standard, and its approach in the sampled models conformed with Ofgem's guidance, with one exception."* |
| ICS Consulting | *"The review concluded that the production and completion of Cadent's NARMS tables have been undertaken in a manner consistent with the published NARMS Methodology."* |
| Costain | *"Investment line costs are accurate, fairly represented, and are in compliance with the RIIO-2 Sector Specific Methodology Decision – Gas, Cadent policy documents and accepted industry principles and standards. "* |
| KPMG | *An analysis of the overall data flow and linkages between the specific files that were reviewed and identification of any issues for resolution by Cadent.* |
| Lloyd's Register | *"Cadent Gas are demonstrating an asset management approach to investment planning and business plan preparation consistent with their externally certified asset management system and industry good practice, and which involves customer engagement, understanding of drivers, analysis of asset condition, performance and criticality data, evaluation of costed options and prioritisation based on risk and other appropriate driver."* |

*Table 54: Summary of Assurance findings*

We are confident that this Investment Decision Pack (Appendix 09.02), and the associated CBA, NARMs and BPDTs, are robust and have been thoroughly reviewed and assured. Our plans have been based on robust corporate data, subjected to both expert and business SME scrutiny and challenge, and then developed, challenged and refined following planned engagement with our Customer Engagement Groups, our senior managers and Board.

Cadent
Your Gas Network



# Appendix 1. Detailed Asset Base Breakdown from RRP 2018/19 Table

| | | PE | | | Steel | | | CI | | SI | | DI | | Other | | Total | Iron <=30m | Iron>30m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | LP | MP | IP | LP | MP | IP | LP | MP | LP | MP | LP | MP | LP | MP | | | |
| Network | Diameter Band | km | km | km | km | km | km | km | km | km | km | km | km | km | km | km | km | km |
| EoE | A | 22,864.8 | 910.4 | 114.0 | 298.2 | 41.9 | 78.3 | 69.0 | - | 36.2 | 0.0 | 1.3 | - | 0.3 | - | 24,414.5 | 104.3 | 2.2 |
| EoE | B | 5,038.0 | 826.3 | 113.5 | 76.7 | 93.8 | 136.0 | 1,265.7 | 2.7 | 1,480.2 | 32.0 | 1,151.3 | 3.3 | 0.6 | - | 10,220.0 | 3,899.6 | 35.6 |
| EoE | C | 2,638.9 | 1,470.6 | 142.1 | 93.3 | 226.6 | 300.1 | 937.4 | 10.8 | 695.8 | 72.1 | 575.3 | 22.8 | - | - | 7,185.8 | 2,233.5 | 80.7 |
| EoE | D | 69.3 | 35.6 | - | 40.7 | 251.7 | 328.6 | 451.6 | 17.4 | 324.6 | 53.8 | 274.2 | 24.5 | - | - | 1,872.1 | 1,080.4 | 66.0 |
| EoE | E | 788.3 | 821.4 | 112.6 | 1.7 | 0.0 | - | 92.1 | - | 7.0 | 0.6 | 0.2 | - | - | - | 1,824.0 | 98.7 | 1.3 |
| EoE | F | 266.3 | 600.9 | 36.7 | 52.6 | 246.5 | 285.9 | 481.0 | 56.6 | 289.5 | 140.4 | 190.7 | 22.7 | - | - | 2,669.8 | 1,049.6 | 131.3 |
| EoE | G | 23.3 | 78.9 | 23.2 | 1.1 | 18.6 | 55.0 | 72.0 | 9.9 | 28.5 | 45.8 | 13.3 | 12.4 | - | - | 381.9 | 144.9 | 36.8 |
| EoE | H | 9.9 | 63.6 | 0.0 | 14.0 | 169.4 | 180.0 | 98.2 | 8.1 | 40.1 | 148.0 | 9.2 | 1.9 | - | - | 742.4 | 252.6 | 52.9 |
| EoE | I | - | - | - | 2.2 | 17.7 | - | 12.2 | 0.1 | 0.1 | 1.5 | - | - | - | - | 33.9 | 13.7 | 0.3 |
| **EoE** | **Total** | **31,698.7** | **4,807.7** | **542.1** | **580.6** | **1,066.2** | **1,363.9** | **3,479.1** | **105.7** | **2,902.0** | **494.3** | **2,215.5** | **87.6** | **0.9** | **-** | **49,344.4** | **8,877.3** | **407.1** |
| NL | A | 7,846.9 | 102.3 | 0.4 | 112.4 | 46.8 | 0.1 | 7.1 | - | 7.0 | - | 2.4 | - | - | - | 8,125.3 | 16.1 | 0.4 |
| NL | B | 2,924.9 | 113.1 | 0.0 | 106.9 | 59.4 | 0.7 | 581.5 | 0.0 | 857.3 | - | 545.7 | 0.5 | - | - | 5,190.0 | 1,977.1 | 7.9 |
| NL | C | 1,171.7 | 124.9 | 1.7 | 32.5 | 81.8 | 28.5 | 551.7 | 0.0 | 513.5 | 0.6 | 266.9 | 0.2 | - | - | 2,774.2 | 1,325.1 | 7.9 |
| NL | D | 13.4 | 7.4 | - | 38.0 | 61.7 | 64.7 | 305.2 | 0.3 | 285.7 | 0.9 | 144.1 | 1.3 | - | - | 922.6 | 729.0 | 8.5 |
| NL | E | 432.1 | 140.9 | 2.7 | 0.0 | - | - | 30.7 | - | 8.1 | - | 0.0 | - | - | - | 614.5 | 37.3 | 1.5 |
| NL | F | 309.5 | 232.2 | 3.6 | 22.5 | 32.7 | 19.3 | 346.9 | 23.4 | 283.1 | 0.1 | 124.8 | 1.9 | - | - | 1,400.1 | 758.8 | 21.5 |
| NL | G | 57.5 | 145.0 | - | 3.9 | 9.6 | 17.9 | 66.5 | 18.6 | 28.3 | 0.0 | 23.9 | 1.6 | - | - | 372.9 | 134.2 | 4.7 |
| NL | H | 19.4 | 61.5 | 2.3 | 23.3 | 79.9 | 103.7 | 259.9 | 58.2 | 34.3 | 7.1 | 24.1 | 0.1 | - | - | 673.9 | 377.2 | 6.6 |
| NL | I | 0.6 | 2.6 | - | 4.8 | 14.2 | 12.0 | 53.2 | 106.7 | 1.5 | 29.7 | - | - | - | - | 225.2 | 187.2 | 3.8 |
| **NL** | **Total** | **12,775.9** | **929.9** | **10.7** | **344.4** | **386.2** | **247.0** | **2,202.7** | **207.2** | **2,018.9** | **38.4** | **1,131.8** | **5.6** | **-** | **-** | **20,298.8** | **5,542.0** | **62.7** |
| NW | A | 16,135.4 | 250.7 | 2.6 | 587.4 | 4.3 | 1.7 | 223.7 | 0.2 | 111.4 | 0.1 | 7.6 | - | 14.3 | - | 17,339.4 | 338.2 | 4.9 |
| NW | B | 3,492.4 | 240.9 | 8.2 | 79.9 | 10.6 | 24.2 | 1,099.3 | 0.4 | 800.4 | 9.7 | 590.5 | 1.3 | 27.7 | - | 6,385.4 | 2,478.3 | 23.2 |
| NW | C | 1,774.3 | 646.0 | 2.3 | 57.1 | 39.0 | 64.4 | 887.6 | 7.6 | 427.6 | 11.0 | 313.6 | 4.5 | 17.1 | - | 4,252.1 | 1,617.4 | 34.6 |
| NW | D | 62.3 | 71.6 | - | 15.6 | 26.4 | 71.3 | 369.8 | 10.9 | 162.6 | 10.6 | 152.9 | 2.2 | 2.9 | - | 959.1 | 686.8 | 22.2 |
| NW | E | 457.8 | 425.4 | 10.8 | 0.9 | 2.2 | - | 120.1 | - | 18.4 | - | 0.4 | - | 0.4 | - | 1,036.2 | 136.7 | 2.2 |
| NW | F | 238.1 | 736.8 | 2.0 | 19.0 | 74.2 | 138.0 | 524.9 | 33.7 | 156.1 | 39.5 | 115.8 | 4.4 | 3.1 | - | 2,085.8 | 829.6 | 44.8 |
| NW | G | 33.1 | 214.0 | - | 1.7 | 6.8 | 37.6 | 135.9 | 11.5 | 28.9 | 9.5 | 12.8 | 1.9 | 1.0 | - | 494.7 | 186.9 | 13.6 |
| NW | H | 18.9 | 105.0 | - | 11.1 | 47.1 | 78.5 | 203.2 | 64.1 | 20.1 | 88.1 | 17.2 | 1.8 | 1.2 | - | 656.3 | 361.7 | 32.8 |
| NW | I | 0.5 | 0.4 | - | 9.0 | 6.4 | - | 38.9 | 2.5 | 3.0 | 0.2 | - | - | - | - | 60.9 | 43.2 | 1.4 |
| **NW** | **Total** | **22,212.8** | **2,690.6** | **25.9** | **781.7** | **217.0** | **415.7** | **3,603.4** | **130.9** | **1,728.6** | **168.6** | **1,210.7** | **16.0** | **67.7** | **-** | **33,269.8** | **6,678.6** | **179.6** |
| WM | A | 9,463.8 | 474.7 | 15.6 | 167.8 | 61.6 | 1.4 | 87.4 | 0.1 | 17.7 | 0.1 | 3.4 | - | - | - | 10,293.6 | 105.3 | 3.4 |
| WM | B | 2,381.9 | 324.5 | 19.0 | 337.2 | 38.8 | 0.8 | 890.3 | 2.3 | 551.2 | 3.7 | 432.3 | 2.4 | - | - | 4,984.5 | 1,857.7 | 24.5 |
| WM | C | 1,258.2 | 462.2 | 29.5 | 168.3 | 59.1 | 4.8 | 666.9 | 15.8 | 304.4 | 71.4 | 205.0 | 11.5 | - | - | 3,256.9 | 1,186.8 | 88.2 |
| WM | D | 3.1 | 21.8 | - | 70.3 | 81.6 | 42.3 | 441.3 | 8.7 | 198.3 | 53.1 | 161.1 | 11.9 | - | - | 1,093.5 | 809.1 | 65.2 |
| WM | E | 336.4 | 436.3 | 19.1 | 1.7 | - | - | 26.4 | - | 2.3 | - | 0.1 | | - | - | 822.3 | 28.5 | 0.3 |
| WM | F | 192.5 | 563.4 | 6.4 | 79.2 | 71.1 | 149.5 | 577.7 | 16.9 | 253.5 | 49.1 | 130.2 | 36.7 | - | - | 2,126.1 | 972.5 | 91.6 |
| WM | G | 14.8 | 88.5 | 0.1 | 10.5 | 15.5 | 15.7 | 186.8 | 1.0 | 45.0 | 0.6 | 7.5 | 2.8 | - | - | 388.6 | 235.3 | 8.3 |
| WM | H | 6.0 | 22.3 | - | 10.3 | 33.2 | 77.6 | 133.3 | 3.0 | 28.7 | 10.9 | 7.6 | 1.6 | - | - | 334.5 | 173.5 | 11.7 |
| WM | I | 0.0 | - | - | 1.4 | 0.4 | - | 30.3 | 0.7 | 4.1 | 0.1 | - | - | - | - | 37.0 | 33.9 | 1.3 |
| **WM** | **Total** | **13,656.7** | **2,393.6** | **89.7** | **846.8** | **361.2** | **292.0** | **3,040.3** | **48.4** | **1,405.0** | **189.1** | **947.3** | **66.9** | **-** | **-** | **23,337.1** | **5,402.6** | **294.5** |

# Appendix 2. Safety Threshold Approach

The risk posed by each gas pipe within 30 metres of a building is risk assessed via the industry-agreed Mains Replacement Prioritisation System (MRPS). MRPS predicts the probability that each pipe will produce an incident. The property incident risk posed by a main is the product of the pipe failure probability, the likelihood of gas entering a property and the probability that gas entering the property ignites resulting in an explosion.

MRPS does not directly predict the risk faced by people exposed to the influence of the main. In order to calculate a risk threshold, it is necessary to convert the probability of an incident into the risk of a fatality for each specific pipe.

Following discussions involving the HSE, Ofgem and all GDNs, it has been concluded an individual risk of fatality of less than 1 in 1,000,000[7] per annum of an individual near to a main (defined as being within 30m) was a broadly acceptable level of hazard that the public would accept.

"Broadly acceptable risks, which are hazards that are deemed to represent an insignificant risk to individuals and society. Acceptable risks apply to any hazard that imposes an individual risk of fatality of less than 1 in 1,000,000 per annum. In this case we would expect that any regulations designed to reduce risks would be disproportionate to the potential risk reduction achieved."

**RIIO-1 Threshold Methodology**

Cadent currently use regional property densities and fatality rate to determine the risk threshold. The average number of properties associated with each LDZ of the network is estimated (using MRPS survey results) to give a property density. Property density is defined as the density of properties adjacent to the main within the network.

The number of fatalities must also be taken into account, as an explosion may result in none, one or multiple deaths. For the purpose of this analysis, the GDNs employed the Industrial Statistics Research Unit at Newcastle University (ISRU) to advise them. ISRU advised that GDNs should use a value of at least 0.444 fatalities per incident to give 99% confidence. Consequently, National Grid (now Cadent) decided to adopt a value of 0.45 fatalities per incident. The above criteria are then combined to give the threshold calculation:

$$MRPS\ Risk\ Threshold = \frac{Property\ Density}{Fatalities\ per\ Incident}$$

The property density is calculated using the specific assets in scope, for example the tier 1 ALARP threshold is calculated using the property density around tier 1 assets and for tier 2a RAT thresholds the property density around these pipes is used. The result is that there are large variations in risk thresholds between each LDZ and pipe type within Cadent's networks.

| | EoE | NL | NW | WM |
|---|---|---|---|---|
| ALARP (Tier 1) | 208 | 220 | 189 | 215 |
| RAT (Tier2a) | 191 | 222 | 165 | 180 |

[7] http://www.hse.gov.uk/research/rrpdf/rr888.pdf

### Evaluation of Current Methodology

The current way that the threshold is calculated assumes a network-wide homogeneous building density by pipe type whereas, in reality, urban areas and rural areas will have different risks associated with them. In addition, the distinction between a threshold associated with Individual Risk and a threshold associated with Societal Risk is not currently made.

When considering Individual Risk, as there is only a single average value for fatalities per incident, the greater the number of buildings surrounding the pipeline, the lower the Individual Risk level will be. This is because if there is an incident from a main it is assumed that one building is affected, the greater the number of buildings around a main means that a person’s individual risk decreases as the risk of the incident being in the building they occupy has been spread wider over more properties.

To better target investment, individual pipe risk thresholds could be considered. However, if this approach is to be taken then it is important to consider the introduction of societal risks as an asset with a high population density (therefore a high safety threshold) may never be selected for safety renewal even though it may have a high incident risk.

When considering Societal Risk, the risk from the pipeline is considered in terms of the entire population that may be affected by an incident rather than just one individual. This risk score considers the probability that any individual will be killed rather than the probability of an individual being killed.

### Proposed RIIO-2 Methodology

**Pipe specific risk thresholds:** To account for the variances in building density, pipe specific thresholds will be calculated based on the pipes specific building density. Building densities will be taken from routine survey data. For each pipe, the length of the entire pipe, and the number of buildings on both sides of the pipe are recorded. These generate the building density, and hence the probability of an individual being the one that experiences the incident that happens. This improved granularity of modelling is made possible by improvements in computing power and makes bets use of our available data.

**Societal risk thresholds:** Societal Risk considers the predicted potential loss of life. The risk posed on a societal level is different from the risk posed on an individual level, and so the acceptable risk level for Societal Risk is different from the acceptable risk level for Individual Risk. The probability that I will be killed in a gas explosion is different to the probability of somebody being killed in a gas explosion. In the example previously given, the construction of a new property adjacent to an at risk pipe reduces the risk of a particular individual being killed but increases (or maintains) the risk that somebody will be killed.

The acceptable risk level for Societal Risk, as determined by the BSI (British Standards Institution), is represented in the figure below. This shows that the likelihood of an incident causing fatalities being broadly acceptable reduces with an increasing number of fatalities. Accidents causing N fatalities are accepted with the frequencies given in the table below. That is to say an incident killing 100 people is more acceptable than one killing 10 people only if the likelihood/frequency of such an event is much lower.

Redacted due to commercial sensitivity

| Number of Fatalities | Accepted Frequency (per year) |
|---|---|
| 1 | |
| 10 | Redacted due to commercial sensitivity |
| 100 | |
| 1000 | |

Using 0.45 as the number of fatalities per incident as before, it can be shown that an MRPS risk score should be greater than 222 x 10-6 incidents per km per year for the average number of fatalities to be above the acceptable risk level for Societal Risk (i.e. to be acceptable). This calculation holds true for all gas mains and is not based on location-specific data. As such, the Societal Risk Threshold will stay the same for all areas and individual distribution mains.

**Prioritisation**

In the interest of deliverability, keeping customers safe and what is reasonably practicable (cost efficiency), we have considered approaches for prioritising the renewal of non-IMRRP mains for RIIO-2. We have carried out a review of the characteristics of the materials that are in scope of our safety approach and propose the following prioritisation of non-IMRRP safety investment:

- prioritisation of replacement for steel pipes above the safety threshold based on MRPS risk score and material standards linked to age (the age criteria is explained below)
- renewal of all asbestos and iron tier 3 pipes above the safety threshold

Regarding non-steel pipes, it is appropriate that all tier 3 iron pipes should be prioritised on the same criterion, namely exceeding the safety thresholds. Asbestos cement behaves in a similar way to cast iron, in that it is a brittle material that tends to fail by fracture. Renewing all asbestos cement pipe above the safety threshold is an appropriate renewal policy.

For steel mains, we carried out a study on the manufacture and installation of steel mains through time. This has resulted in a proposal to prioritise mains based on pipe age, which considers improvements in material quality, coating, jointing and installation. The lens of construction quality helps to further target the highest safety risk pipes within the above threshold category. These prioritisation criteria are only applied to the pipe-specific risk threshold, if the pipe is above the societal risk threshold it will be promoted for renewal (the social threshold acts as a safety backstop, ensuring assets with high incident probability are captured for renewal).

**Summary**

Pipes which breach either the pipe specific or societal thresholds will be candidates for replacement. With prioritisation for steel based on the year the asset was laid.

| | LP | MP | IP |
|---|---|---|---|
| **Iron Tier 1** | IMRRP | | |
| **Iron Tier 2** | Renew if above either pipe specific or societal safety threshold | | |
| **Iron Tier 3** | | | |
| **Steel Tier 1** | Renew if:<br>1. above pipe-specific safety threshold, within a high-risk age band and has no maintained cathodic protection<br>2. above higher safety threshold and no maintained cathodic protection (no risk bands applied) | | |
| **Steel Tier 2** | | | |
| **Steel Tier 3** | | | |
| **Asbestos Tier 1** | Renew if above either pipe specific or societal safety threshold | | |
| **Asbestos Tier 2** | | | |
| **Asbestos Tier 3** | | | |

All other pipes which do not breach either risk threshold should be constantly monitored for changes in risk score arising from incidents, GiBs, new survey data or new MRPS coefficients.

**Note on Fatality Factor**

Individual Risk takes into account the predicted number of incidents per pipe per year multiplied by the number of fatalities per incident. This is because, in the event of an incident, not all of the population within a building will become fatalities. Thus, a scaling factor is applied to understand the average number of fatalities that would occur. This scaling factor has been 0.45 fatalities per incident as previously described by ISRU. However, it has been noted that this scaling factor should be divided by the average number of people per household in the UK, which is around 2.38. This places the scaling factor at approximately 0.19 fatalities per person per incident.

We to continue using the fatality rate approach rather than updating it to an individual's risk exposure. This is on the basis that we have been using the fatality rate to set risk thresholds in RIIO-1 and changing this value will loosen the safety thresholds customers have benefited from in RIIO-1. The HSE and customers would not welcome a reduction in safety standards.

# Appendix 3. DNVGL MRPS Steel Model Review

The MRPS Steel model was developed by the industry at the same time as the iron models and agreed with the HSE as part of the roll-out of MRPS. However, it has not previously been actively used to identify replacement activity.

We therefore commissioned a review of the model to ensure its validity for the intended purpose. The outputs of that review are embedded here.

‘Validity of MRPS Steel Model (Final).pdf’ document available on request.

# Appendix 4. CBA Approach

We have consistently followed best practice, including HM Treasury Green Book, Ofgem RIIO-2 guidance, and the NOMS framework in applying CBA.

The methodology we have developed considers a range of options, with costs across five cost categories:

- Safety – impact on the frequency of non-fatal injuries and the risk of fatalities.
- Environment – impact on emissions.
- Customer – impact on reliability (e.g. interruptions) as well as other impacts such as avoiding property damage and transport disruption.
- Financial
  - Upfront capital cost
  - Opex – impact on our work delivery costs
  - Efficiency – impact on the delivery of the repex programme

Our cost-benefit analysis is based on the unit costs of replacing mains as opposed to an alternative remediation solution. The only alternative available to us at this moment is CISBOT; however, this has not been factored in as it is only applicable to larger diameter iron pipes and is dependent on the condition of the asset, as it is a joint remediation only technique.

**Approach to NPV analysis**

Our approach to net present value (NPV) analysis considers the wider societal benefits of completing mains replacement. The following section covers the principles that we have applied.

The key factors within any NPV analysis are:

- Agreeing the baseline and options to model and appraise, with each representing differing levels of investment, and impacts on the five cost categories
- Estimation of financial costs and impacts
- Valuation of societal costs and benefits (and how these change in differing investment options)
- Appropriate discounting of all societal and financial costs over time, consistent with HMT Green Book and Ofgem guidance

**Estimation of costs**: to value investment we have developed detailed cost models which take into account the major cost drivers based on the actual costs observed in RIIO-1.

**Valuation of societal costs and benefits:** in our valuation of societal costs and benefits we have used the following methodologies:

- Safety – we have appraised safety levels through considering the likelihood of an incident (driven by MRPS scores); this is monetised using agreed HSE and Ofgem valuations, which align with the NOMS approach.
- Emissions – we have appraised the levels of emissions using our leakage models; these are monetised using the cost of carbon forecast (as published by DEFRA)
- Customer – customer disruption (e.g. reliability) is based on the NARMs methodology; we have valued these values from our own customer research and the value transfer literature
- Financial – we have estimated work delivery savings associated with avoidance of future mains repairs including the impacts of deterioration on our repair rates. Valued based on our actual repair rates and unit costs

## Paybacks in CBA

The application of Ofgem's guidance in CBA, results in upfront capital costs being spread over the life of the investment, reflecting the way in which the costs impact on bills. The costs per year are thus much reduced from the actual investment levels in each year.

Illustration

Consider a *XXXX* investment which generates *XXXX* of benefits per year (e.g. avoided costs, environmental risk reductions, etc).

The *XXXX* of investment is recovered through customer bills over time (through finance costs and depreciation). Using a capitalisation rate of 100% (as per Ofgem's guidance for repex) and our WACC of *XXXX*, this would result in costs to be recovered of *XXXX* across a five-year period:

- Redacted due to commercial sensitivity
- And so on….

Note: year one will be low as there are no depreciation costs until year 2.

This project would immediately payback for our customers – they would experience higher benefits than costs from the first year of investment (i.e *XXXX* of costs and *XXXX* of benefits in the first year).

If we did not capitalise the investment – then this project would not pay back for several years. In this example it would take 11 years for the discounted sum of the benefits to exceed the discounted costs.

This shows that where capitalisation rates are high, and where benefits are relatively large and emerge early in the programme, it is possible to get very short paybacks against discounted capital expenditure.

We have followed Ofgem's guidance in discounting and setting capitalisation rates. We have calculated paybacks using a clear definition: the point at which the discounted stream of benefits to our customers starts to exceed the discounted stream of costs they incur through their bills.

Illustration – portfolio effects

In our portfolios of work (e.g. mains replacement) there will be a mixture of schemes that have different costs and benefits, NPVs and payback periods.

When looking at the portfolio as a whole those projects with a short payback will counterbalance those with longer payback – to give the average payback for the portfolio.

For example, a portfolio with three schemes with individual payback periods of 5 years, 10 years and 20 years may have an average payback of c. 12-15 years (depending on the level and profile of costs). This would be a good payback for the portfolio.

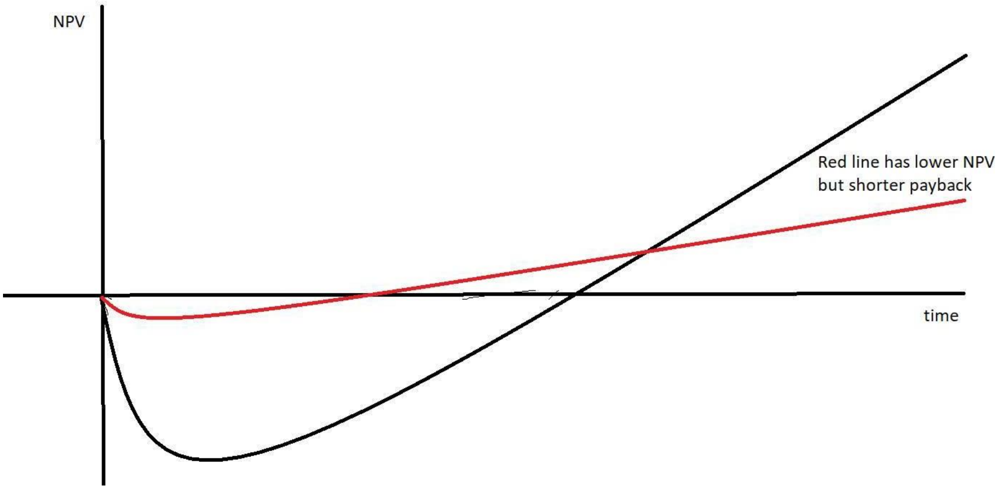
We have strived to ensure projects that make up our investment portfolios do have reasonable payback periods and maximise cost benefit within the constraints set.

Illustration – high payback versus high NPV

We recognise that NPV and payback are not the same.

In seeking the best solution, we aim to maximise whole life benefits (NPV) subject to constraints. We have, however, questioned the validity of positive NPV portfolios with long paybacks (for example, if benefits accrue quite far into the future).

In the figure below, we demonstrate this point. In this example we can choose between two scenarios represented by the black and red lines. From a purely economic point of view, the black line is preferable as it has the highest NPV. The red line has a shorter payback period, i.e. the point at which the discounted stream of benefits to our customers starts to exceed the discounted stream of costs they incur through their bills occurs sooner. As such in choosing the right investment option for our customers we would consider both the NPV and the payback, in relation to overall expenditure.




We consider it important to consider the CBA results without applying formulaic rules. We have always considered and balanced our legal duties, affordability, value for money and payback in reviewing and finalising our investment plans.

**CBA pipes in the mains model**

The mains programme is quite distinct in how we have developed our plans, as we have considered all of our mains collectively (in our decision support tool AIM). This is the IMRRP, safety mandated and CBA plans.

In AIM we consider all mains together. We set constraints to ensure mandated investment is picked (IMRRP flat run rate, all pipes above safety threshold in RIIO-2) ; we have also set constraints on the maximum non-mandated CBA work that can be selected. The objective function is set to minimise the whole life costs (maximise NPV) of mains subject to meeting these constraints. This means we will meet our mandated obligations at least cost; and we will select any additional cost beneficial investment within the length constraint.

This approach to assessing our mains programme ensures that we do not double count or miss valuable investment – and ensures we get the biggest return for our customers on investment made, whilst being affordable to our customers.

By including CBA pipes in the optimisation run we identify sections of pipe with positive NPVs. We also look to create Superstrings – where we link pipes for investment together for efficiencies: AIM will select schemes which have a higher NPV when combined as superstrings than would exist without the CBA element.

NB: Without superstrings, two safety pipes invested in separately incurs two sets of fixed costs (e.g. setup, planning, project management, etc); adding another intermediate pipe to form a single scheme can save some of these fixed costs, improving the overall value for customers.

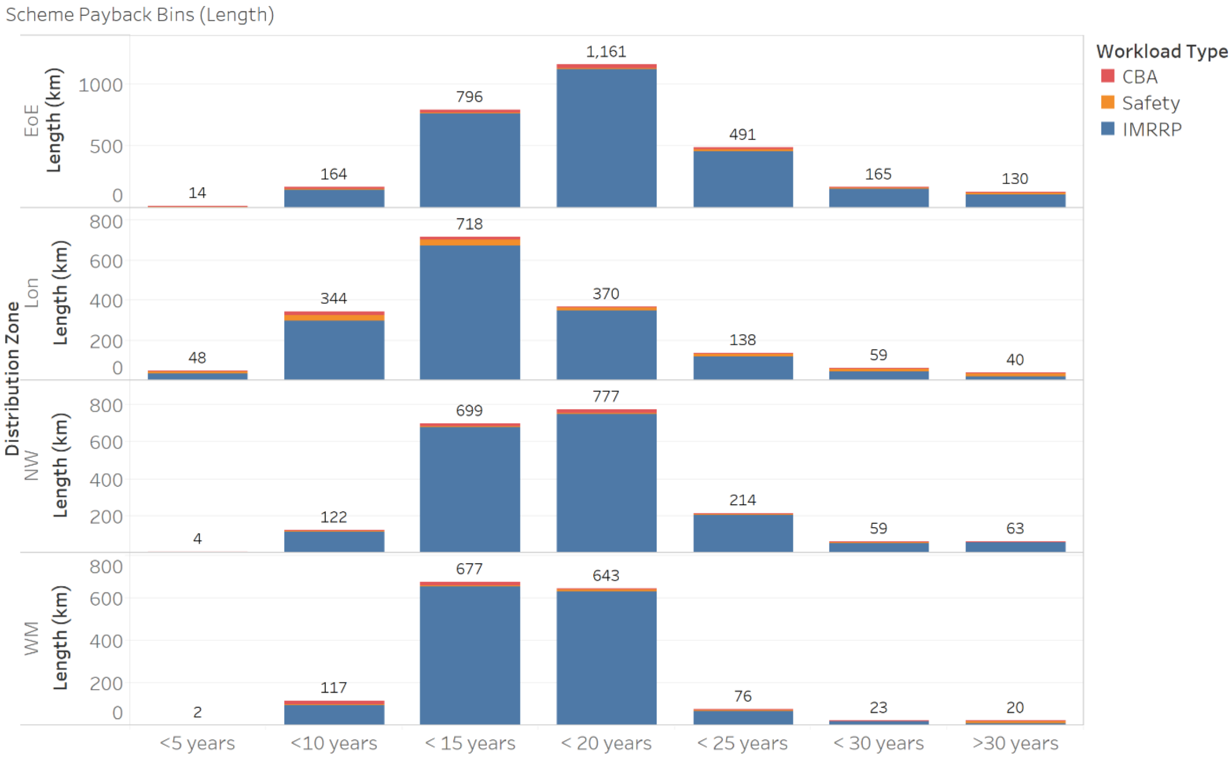
As such the AIM model may pick:

1. Pipes that deliver to mandated safety requirements
2. Pipes that form superstrings, and 'connect' to the mandated safety driven pipes, and which would not be picked on NPV on their own, but when combined with other pipes improve the overall NPV.
    - For example, a short (high mobilisation cost) section of safety driven steel if combined with the adjacent pipework (a mid range NPV scheme) can create a combined scheme which has greater NPV than the short steel pipe and a separate NPV positive scheme alone. By definition these additional pipes reduce the overall costs of the work, reducing the payback than (1) would have on its own. These may still have a long payback – but it will be shorter than doing the pipes in (1) alone.
3. Pipes with high NPVs (subject to any constraints e.g. length).

Hence, while a CBA pipe may not have the best benefits when considered in isolation, the lower costs from combining this with other work can make it worth doing (i.e. the additional marginal costs are lower than the additional marginal benefits). Moreover, this improves the NPV and Payback of the Safety/IMRRP pipes.

The outputs of our models show the costs and benefits of whole schemes, i.e., combined benefits and the cost of delivering the full scheme.

Length vs payback year in five year bands (split by distribution zone, coloured by workload type):




The graphs show an payback by region (from the end of RIIO-2) of: EoE 19 years, LON 10 years, NW 18 years and WM 17 years. With a Cadent payback of 15 years.

Whilst the majority of our safety driven investment pays back within 20 years, we could not meet our safety mandated work programme without replacing some pipes with paybacks greater than thirty years.

By allowing the model to pick additional pipes beyond the safety programme on the basis of CBA, we achieve two effects:

1. We are able to replace some high NPV pipes (3) which bring rapid benefits to customers in terms of reduced opex spend (repairs) and reduced interruptions to supply.
2. We are able to reduce the payback periods of safety mandated work (2) by building more cost effective connected schemes.

Removal of the CBA work that paybacks over 30 years would make the other mandated pipes less economic and extend its payback further. Most post 30 years CBA investment is quite small lengths of pipes, although there are some lengths that connects lots of small safety driven lengths. Either way, these schemes provide significant efficiencies into the programme.

<u>The benefit of CBA</u>

To demonstrate this, consider the Safety portfolio (predominately steel replacement). We have estimated that removing all of the CBA programme would significantly reduce the scope for efficiencies in delivery resulting in increased cost (e.g. increasing fixed set up costs from more piecemeal work), lower NPV and worsen paybacks.

| Safety Workload | Cost | NPV | Payback |
| --- | --- | --- | --- |
| With CBA | Redacted due to commercial sensitivity | | |
| Without CBA | | | |

This applies similarly to IMRRP.

In summary, our overall strategy is to deliver a safe, reliable and efficient service, whilst ensuring affordable bills for our customers. We have balanced legal compliance, economic value and paybacks in developing and finalising our plans. Our CBA work provides efficiencies in delivery which delivers value for our customers.

# Appendix 5. HSE Enforcement

The HSEs approach to enforcement of the IMRRP (2013-2021) is set out on their website.

http://www.hse.gov.uk/gas/supply/mainsreplacement/enforcement-policy-2013-2021.htm

Relevant extracts are cited below:

"The Health and Safety Executive's (HSE) enforcement policy for the Iron Mains Risk Reduction Programme (IMRRP) addresses the failure of 'at risk' iron gas mains (i.e. those pipes within 30 metres of buildings) and the consequent risk of injuries, fatalities and damage to buildings. It is designed to secure public safety while allowing efficiency, environmental, strategic and customer service factors to contribute to driving the programme and allowing sufficient flexibility to enable the Office of the Gas and Electricity Markets (Ofgem) to incentivise innovation in risk management."

The enforcement policy for 2021-2026 will be updated during the RIIO-2 planning process.

# Appendix 6. Additional Photographs Showing Real Life Examples of Mains and Services Work

*Steel and PE mains*

*Cast iron main with PE service tee*

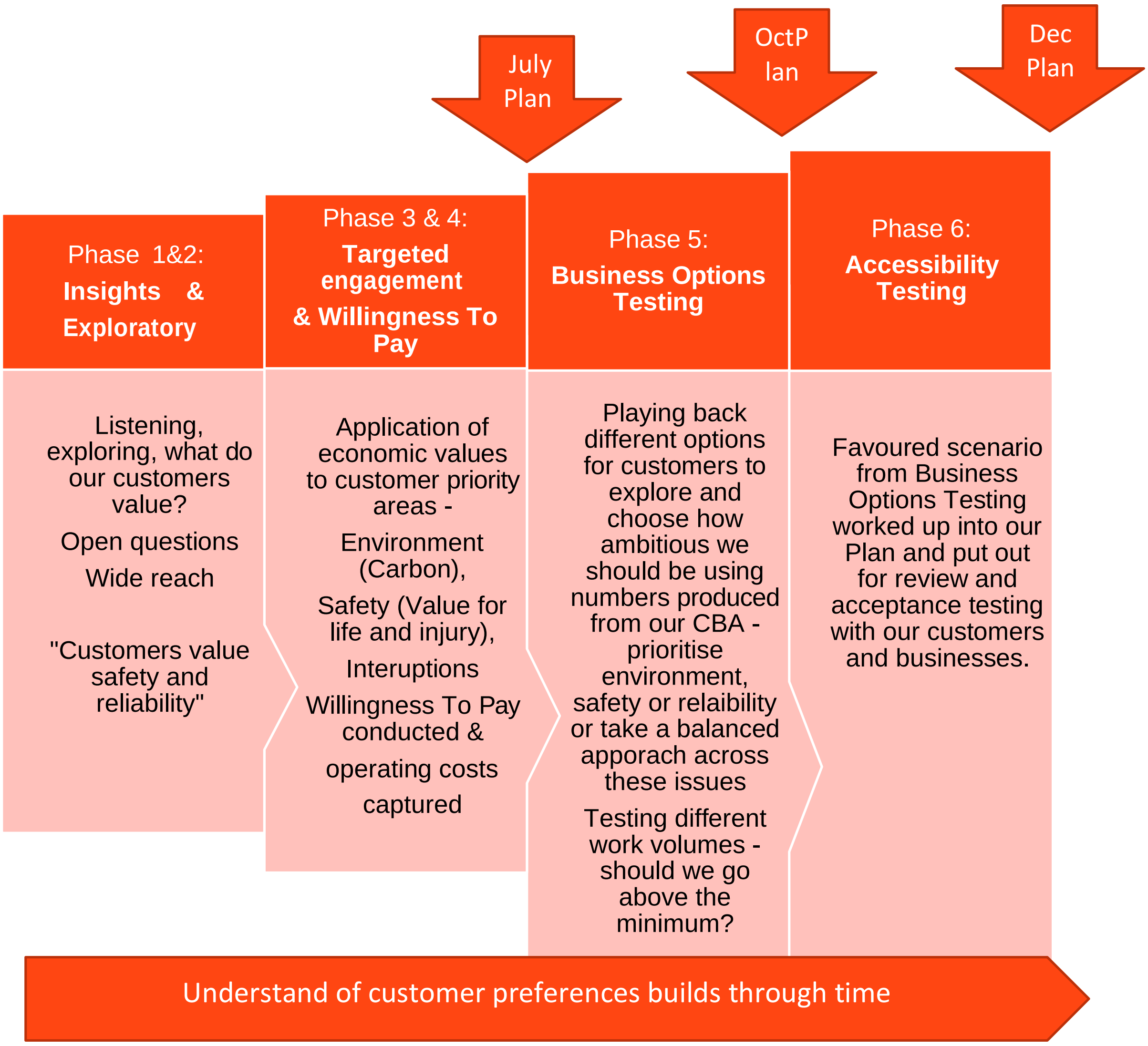
*Cast iron main and service tee*

# Appendix 7. Customer Engagement

Our overarching approach to Engagement is presented in Chapter 5 of our Business Plan submission, supported by a detailed engagement appendix.

This section summarises a number of key engagement areas relating specifically to our mains replacement programme, this has included Quantitative Survey, Customer Forums, Future Customer, Focus groups and Employee Workshops.

Customers have been at the heart of shaping the plans we have outlined above; these plans are now subject to a final round of testing ('acceptability research').




**Business Options Testing (BOT)**

Our July business plan submission showed the scenarios we had developed following primary engagement and economic modelling. These scenarios were tested with customers through the summer. The results have driven the investment plan. The slides below describe the results of the BOT.

Cadent Your Gas Network

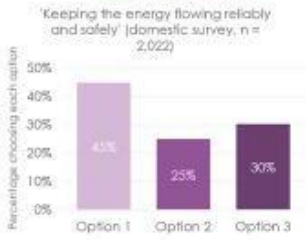
# Quantitative Survey
# 2920 participants

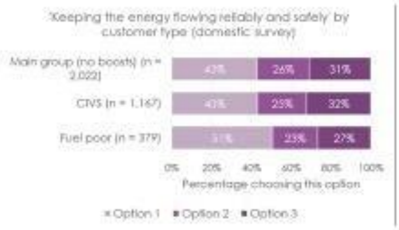
## Keeping the energy flowing reliably and safely — Domestic customers

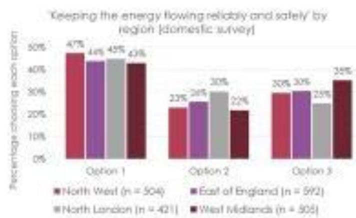
- To improve the safety of the network, all Gas Distribution Networks have a duty to replace all of their old iron pipes with plastic pipes. This work must be completed by 2032.
- Plastic pipes have benefits over the old metal pipes, as they last longer and are less likely to leak. As well as being safer, this means that customers' gas supplies are less likely to be interrupted and the environment is less likely to be harmed by leaking gas.
- During the next five years, Cadent could replace more pipes than the legal minimum, to brin the benefits sooner.

| | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| What Cadent could do during this period* | 592 km replaced per year: • Reduction in likelihood of explosions from 1 in 1.5 years to 1 in 3.1 years. • Reduction in number of interruptions of 8%. • Reduction in greenhouse gas emissions of 19%. | Additional 20 km replaced per year in your network: • Reduction in likelihood of explosions from 1 in 1.5 years to 1 in 3.3 years. • Reduction in number of interruptions of 12%. • Reduction in greenhouse gas emissions of 22%. | Additional 40 km replaced per year in your network: • Reduction in likelihood of explosions from 1 in 1.5 years to 1 in 3.4 years. • Reduction in number of interruptions of 15%. • Reduction in greenhouse gas emissions of 24%. |
| Additional cost on customer bill per year* | £3.79 | £3.95 | £4.17 |

*East of England table displayed; participants saw tables customised for regional and improvements and costing.

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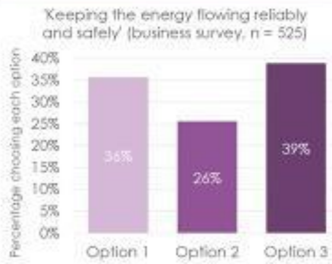
Cadent Your Gas Network

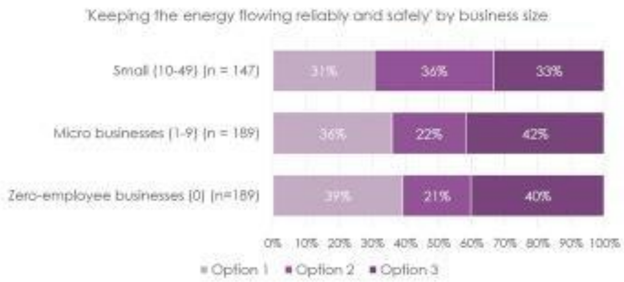
# Quantitative Survey

## Keeping the energy flowing reliably and safely: business survey




Compared to the average shown on the left:

- Some industries were much more likely to choose Option 3: Health & Social Work (45%) and Arts, Entertainment and Recreation (64%).
- Some industries were much more likely to choose Option 1: Professional, Scientific and Technical Activities (45%); Accommodation & Food Services (50%) and Wholesale & Retail Trade and Motor Vehicles (50%).

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Cadent Your Gas Network
Customer Forum
198 participants
FINDINGS – REPLACING PIPES WHAT WE DID
Session objective: To understand:
• What risks customers prioritise when replacing mains pipes
• If these risks are more or less important to customers than bill impact
• If customers prefer smooth bills
• If customers consider different risks for flats and apartments and Cadent sites.
What we did:
• As part of an interactive session, participants were asked to prioritise Cadent's pipe replacements (by safety, environmental impact or minimising disruption) and discuss how they would want to pay for it.
• Participants in Ipswich were also asked whether their priorities would change when looking at Cadent sites, while participants in London were asked whether their views had changed after seeing the London Pipes Replacement Map.
Voting:
• Participants were asked to vote on which of the five options they preferred.
• (London & Ipswich only) Participants were asked to vote on which of the five options they preferred for flats and apartments.
• In both votes, some participants voted for multiple options. This has meant the total number of responses is higher than the number of participants.
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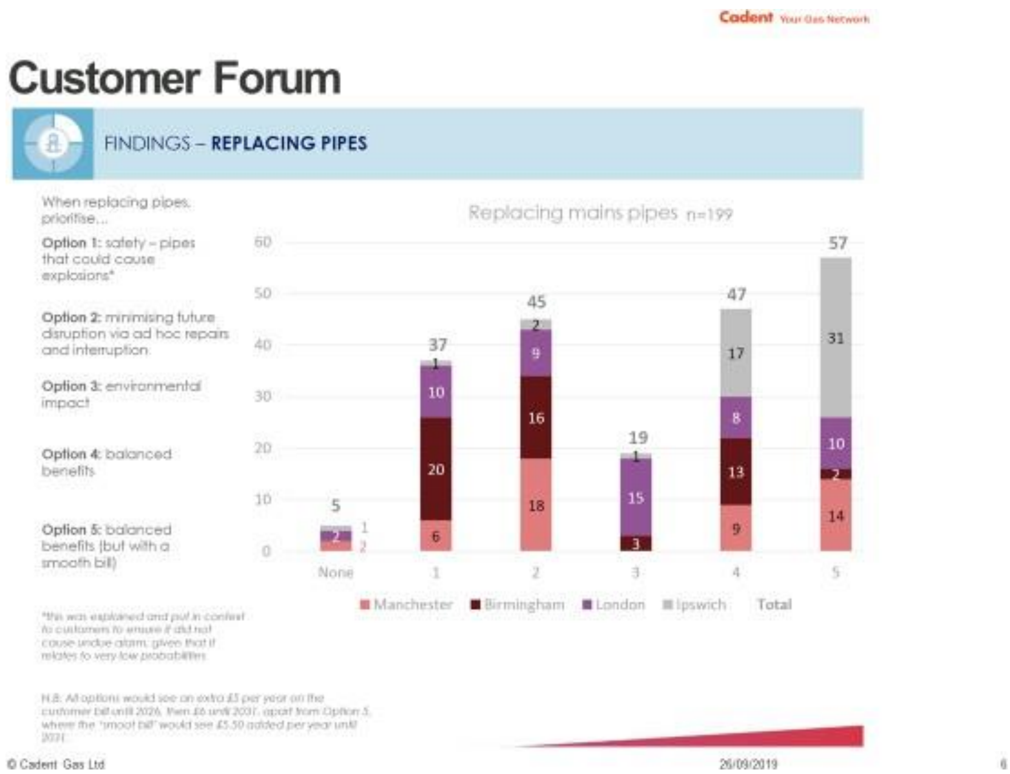
Cadent Your Gas Network
Customer Forum
FINDINGS – REPLACING PIPES
When replacing pipes, prioritise...
Option 1: safety – pipes that could cause explosions*
Option 2: minimising future disruption via ad hoc repairs and interruption
Option 3: environmental impact
Option 4: balanced benefits
Option 5: balanced benefits (but with a smooth bill)
Replacing mains pipes n=199
0
10
20
30
40
50
60
5
37
45
19
47
57
None
1
2
3
4
5
Manchester
Birmingham
London
Ipswich
Total
*this was explained and put in context to customers to ensure it did not cause undue alarm, given that it relates to very low probabilities
N.B. All options would see an extra £5 per year on the customer bill until 2026, then £6 until 2031, apart from Option 5, where the "smoot bill" would see £5.50 added per year until 2031.
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## Customer Forum

FINDINGS – **REPLACING PIPES**

- Overall, when replacing mains pipes **Options 4 & 5 (balancing the benefits; and with smooth bills) were the most popular.** These two options combined (i.e. to understand the overall level of support for balancing the benefits) accumulated half the overall vote (47%).
  - Options 4 & 5 were most popular in Ipswich, where all bar 6 of the 54 participants voted for one of those options.
- When these options were applied to flats and apartments, it was similar overall – **options 4 & 5 combined were the most popular** – but the gap between priorities was less sharp.
  - In London the majority of participants didn't answer this question, and of those who did, Option 1 (prioritising safety) was the most popular.
- Consensuses were reached fairly early in most discussions, that for general road replacement pipes, **Options 4 and 5**, which allowed for a spreading of benefits across the three areas, were best.

*"Still safety prioritised, but if you're saying the effort going into it varies, just get it all done in one push."*

- **Safety became a bigger issue when participants discussed flats and apartments**, where more people were affected (although this was also recognised in relation to repairs and disruption).
  - The Grenfell Tower fire was brought up independently a number of times, including outside London.
- *(Ipswich only)* When discussing the options in relation to Cadent sides, there was a general acceptance that safety and disruption should be more important than in previous discussions.
- *(London only)* There was fairly little change in opinion when discussing the London-specific pipe replacement, although it was acknowledged that **closures and disruption are fairly common in London already**.

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## Future Customer focus groups
## 48 participants

| Topic | Objective | Driver |
|---|---|---|
| Replacing pipes | Find out how customers think Cadent should best approach pipe replacement. | This topic is related to decarbonisation, and also represents the biggest impact on the bill, and will be paid for over a longer period |

FINDINGS – REPLACING PIPES

Participants were presented with four different options for how Cadent could approach their pipe replacement process and asked to rank them in order of preference. The options and pipe replacement process was simplified in order to ensure comprehension by participants. The options were:

1. Safety First! (best safety improvement)
2. Fix it Up (fewest repairs & fewest interruptions)
3. Eco Warrior (best for the environment)
4. Balance it Out (balance of different benefits)

FINDINGS – REPLACING PIPES

- Participants were asked to vote on which of the options they preferred. Some participants voted for multiple options. The count of votes is represented in the graph below
- Overall views were fairly mixed as to the best option, although the balanced approach (option 4) was preferred most often by participants, and those who preferred option 2 chose it because they felt it gave a good balance across different priorities.


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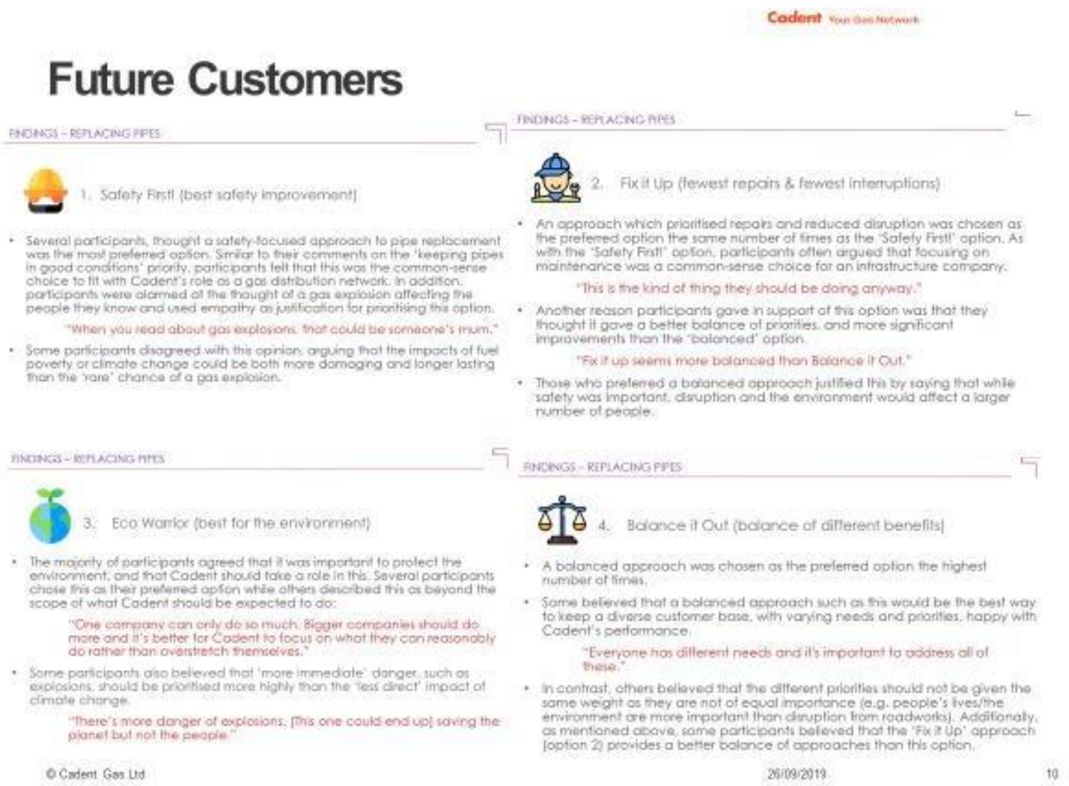

Cadent Your Gas Network

## Future Customers

FINDINGS – REPLACING PIPES

1. Safety First! (best safety improvement)

- Several participants, thought a safety-focused approach to pipe replacement was the most preferred option. Similar to their comments on the 'keeping pipes in good conditions' priority, participants felt that this was the common-sense choice to fit with Cadent's role as a gas distribution network. In addition, participants were alarmed at the thought of a gas explosion affecting the people they know and used empathy as justification for prioritising this option.

  "When you read about gas explosions, that could be someone's mum."

- Some participants disagreed with this opinion, arguing that the impacts of fuel poverty or climate change could be both more damaging and longer lasting than the 'rare' chance of a gas explosion.

FINDINGS – REPLACING PIPES

2. Fix it Up (fewest repairs & fewest interruptions)

- An approach which prioritised repairs and reduced disruption was chosen as the preferred option the same number of times as the 'Safety First!' option. As with the 'Safety First!' option, participants often argued that focusing on maintenance was a common-sense choice for an infrastructure company.

  "This is the kind of thing they should be doing anyway."

- Another reason participants gave in support of this option was that they thought it gave a better balance of priorities, and more significant improvements than the 'balanced' option.

  "Fix it up seems more balanced than Balance it Out."

- Those who preferred a balanced approach justified this by saying that while safety was important, disruption and the environment would affect a larger number of people.

FINDINGS – REPLACING PIPES

3. Eco Warrior (best for the environment)

- The majority of participants agreed that it was important to protect the environment, and that Cadent should take a role in this. Several participants chose this as their preferred option while others described this as beyond the scope of what Cadent should be expected to do:

  "One company can only do so much. Bigger companies should do more and it's better for Cadent to focus on what they can reasonably do rather than overstretch themselves."

- Some participants also believed that 'more immediate' danger, such as explosions, should be prioritised more highly than the 'less direct' impact of climate change.

  "There's more danger of explosions. [This one could end up] saving the planet but not the people."

FINDINGS – REPLACING PIPES

4. Balance it Out (balance of different benefits)

- A balanced approach was chosen as the preferred option the highest number of times.
- Some believed that a balanced approach such as this would be the best way to keep a diverse customer base, with varying needs and priorities, happy with Cadent's performance.

  "Everyone has different needs and it's important to address all of these."

- In contrast, others believed that the different priorities should not be given the same weight as they are not of equal importance (e.g. people's lives/the environment are more important than disruption from roadworks). Additionally, as mentioned above, some participants believed that the 'Fix it Up' approach (option 2) provides a better balance of approaches than this option.

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<u>Notes on BOT:</u>

Our approach to business options testing has allowed us to hear a range of customer voices and gain a deeper understanding of how customers viewed our initial plans. We should not, however, be looking at any item (region) within this research in isolation but rather considering its output as a whole.

In terms of numbers, there were circa 50 attendees at the Customer forums (x 4 workshops). We also covered NARMS with future customers (12 attendees x 4 sessions) and at a session with our own employees (80 attendees). So 228 individuals in total.

'The sample sizes for the customer forums are not sufficient for making business plan decisions, in terms of quantitative data gathered from the voting activity – the forums were not intended to provide regional answers to the questions asked. The value of the forums lies instead in understanding what participants think, what they prioritise, what ideas they have, what they understand by the information presented to them. Taking the customer forum participants across all four locations together, the preference for the balanced bill (i.e. options 4 and 5 together, since 5 is the smooth balanced bill) is extremely clear. If, for example, we take Birmingham alone, three options (i.e. 1, 2 and 4/5) each received between 15 and 20 votes. The reasons people gave for their preferences were not different to those elsewhere: some participants felt that no potential loss of life would be justifiable, and therefore chose safety, while others recognised that the safety risks are low, and prioritised resilience or a balanced bill instead. The nature of small group discussion is such that people at a given table can be swayed by the discussion they have, so it is normal to see variation between different tables, and different locations: in London for example, Option 3 was very strong; in Ipswich almost the entire room voted for 4/5. This is why the business options testing programme included a quantitative research strand with a large sample size, offering a robust basis for making business plan decisions, as well as covering topics with multiple groups in qualitative research. The qualitative research gives the 'why' behind decision-making, so small differences in choices made between locations are to be expected, and add to the richness of the data gathered, as we can see the range of opinion surfaced during the discussion.' Traverse

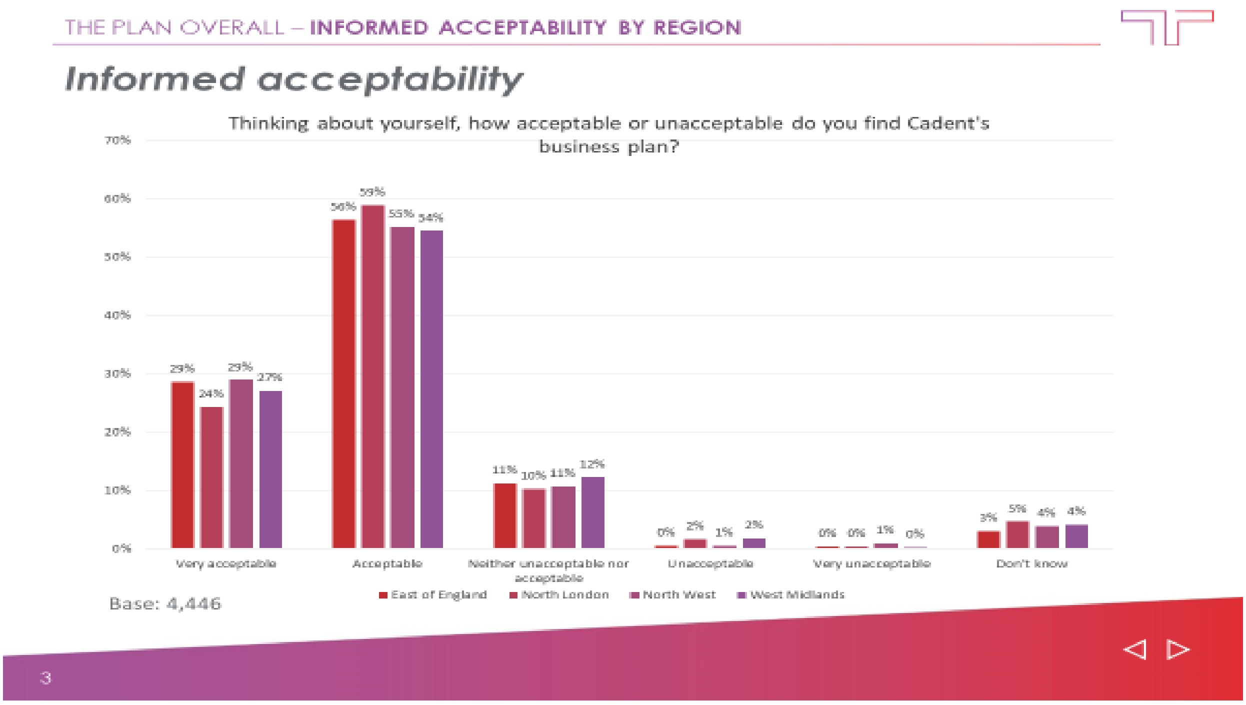
**Acceptability Testing**

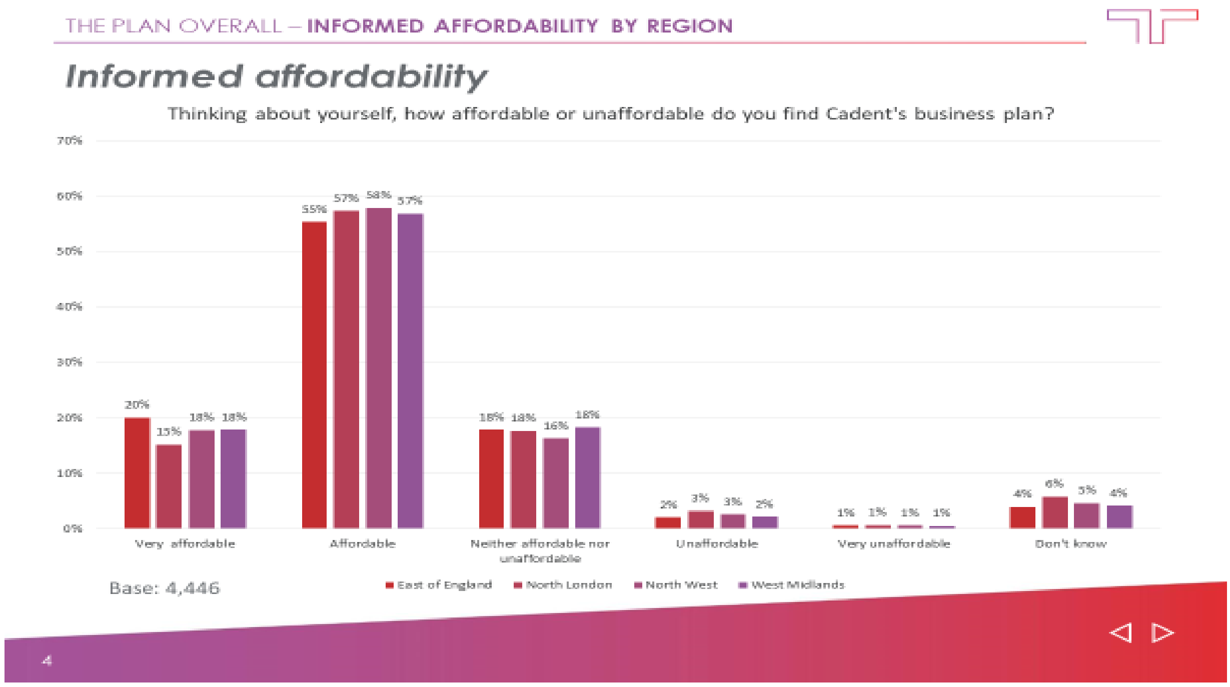
The slides below show the results for acceptability and affordability testing carried out with customers, businesses and stakeholders. The first set of results shown are for the plan overall.

Results from the quantitative survey (4,400 participants) are set out below.

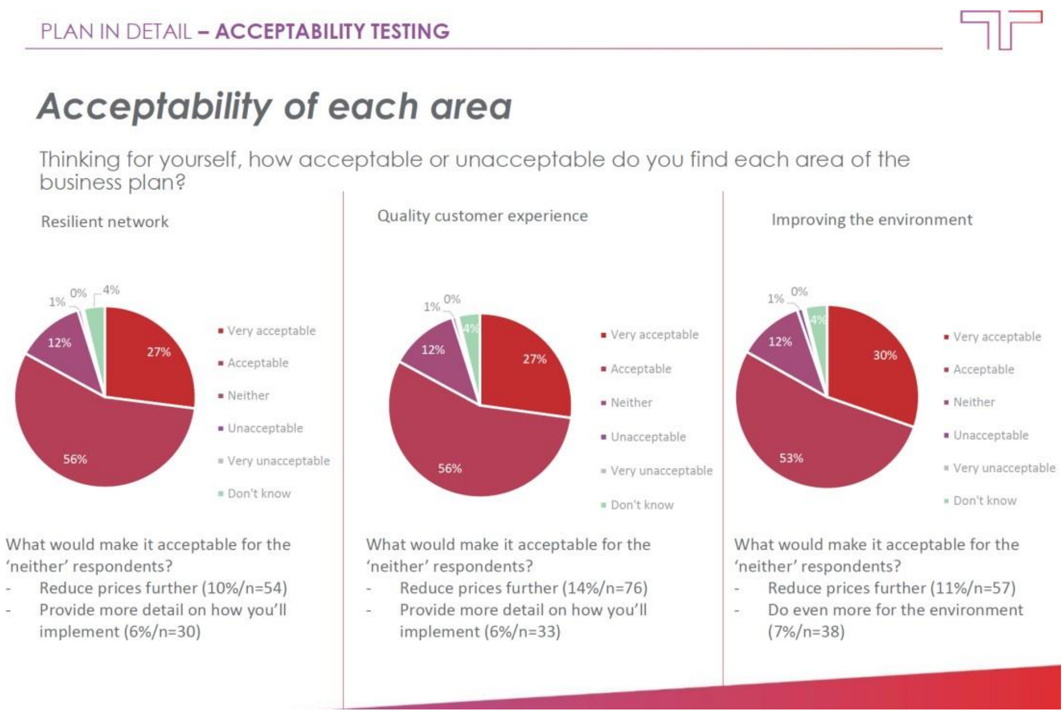
| Engagement Approach | Informed or Uninformed? | Business Plan Acceptability (%)? | Business Plan Affordability (%)? |
|---|---|---|---|
| Domestic customers - Survey | Uninformed | 83% | 75% |
| Domestic customers focus groups | Uninformed | 78% | 67% |
| Domestic customers – Customer forums | Informed | 94% | 91% |
| Businesses - Survey and interviews | Uninformed | 84% | 77% |
| Fuel poor customers focus groups | Uninformed | 74% | 71% |
| Future customers focus groups | Uninformed | 85% | 80% |
| CIVS interviews | Informed | Yes* | Yes* |

* We interviewed 20 Customers In Vulnerable Situations (CIVS) (1 hour interview). Whilst they were asked whether our plan is acceptable and affordable. This was qualitative data and no clear % rating can be deduced from this.






The following slides provide results specifically in relation to providing a resilient network.



PLAN IN DETAIL – **ACCEPTABILITY TESTING**

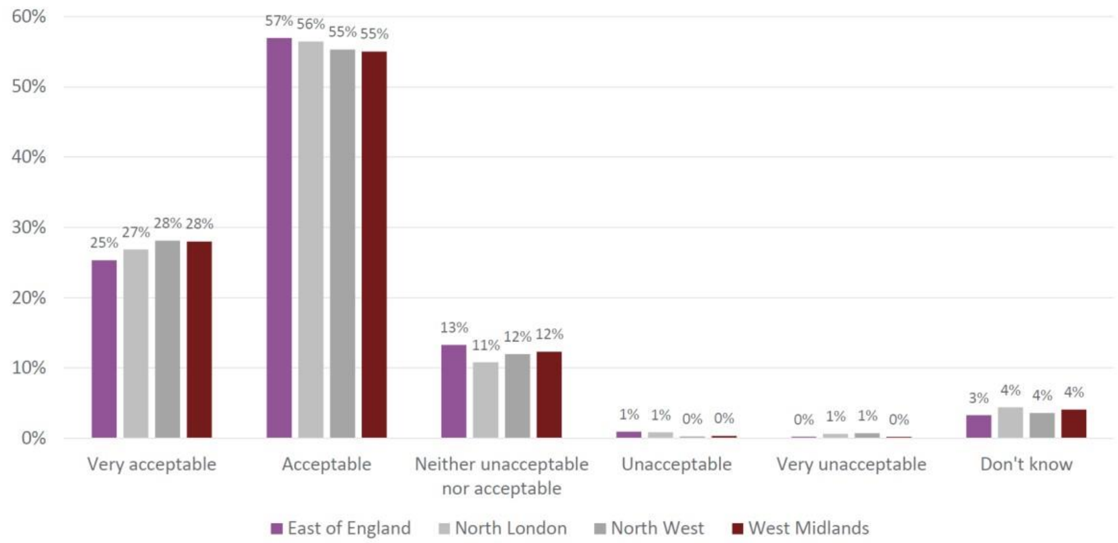
## *Importance of each area*

How important do you think each of the three areas are for Cadent's business plan?


PLAN IN DETAIL – **RESILIENT NETWORK**

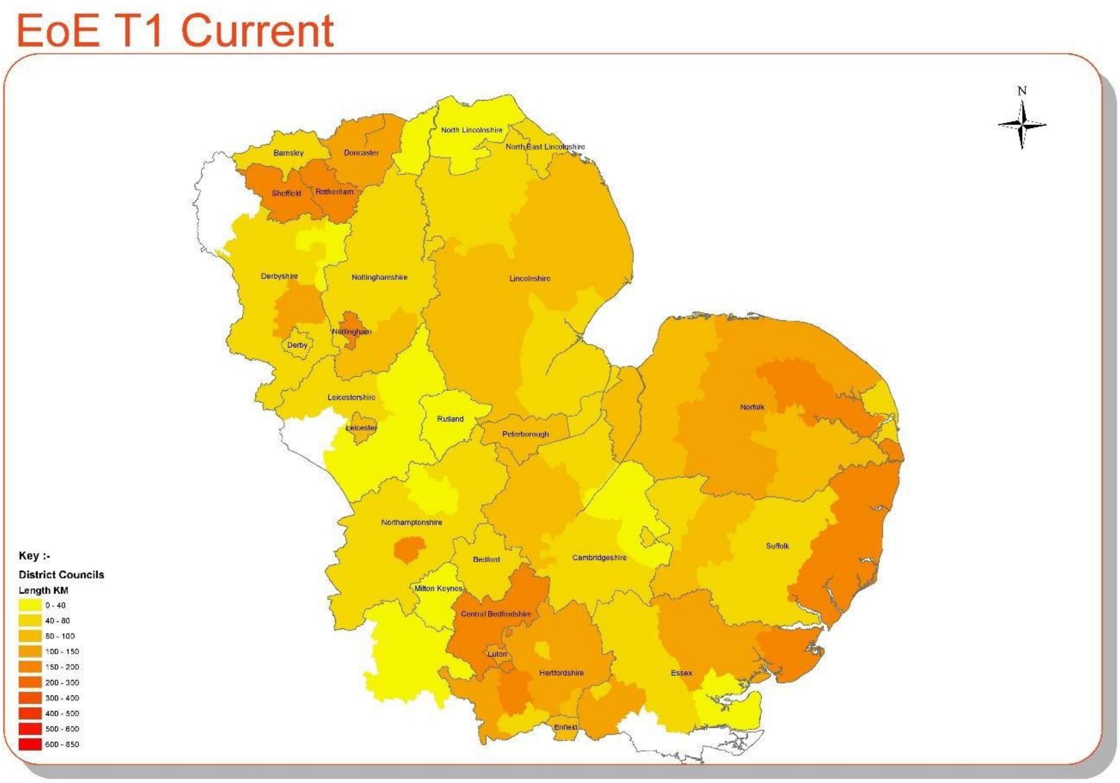
## *Acceptability of Resilient network*

How acceptable or unacceptable do you find Cadent's plan to maintain a resilient network?

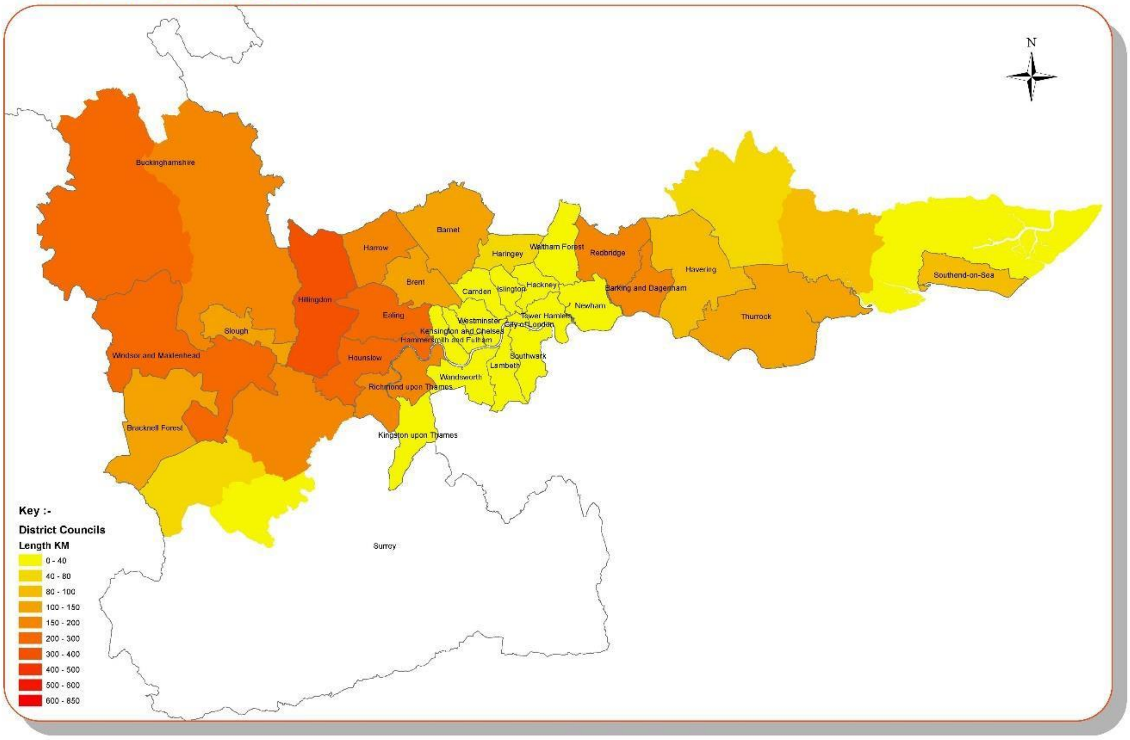


# Appendix 8. Distribution of IMRRP by Local Council

The images below help to demonstrate how our work is distributed across our regions. The maps produced have been used as an input to stakeholder discussions about our future delivery plans.



# NL T1 Current



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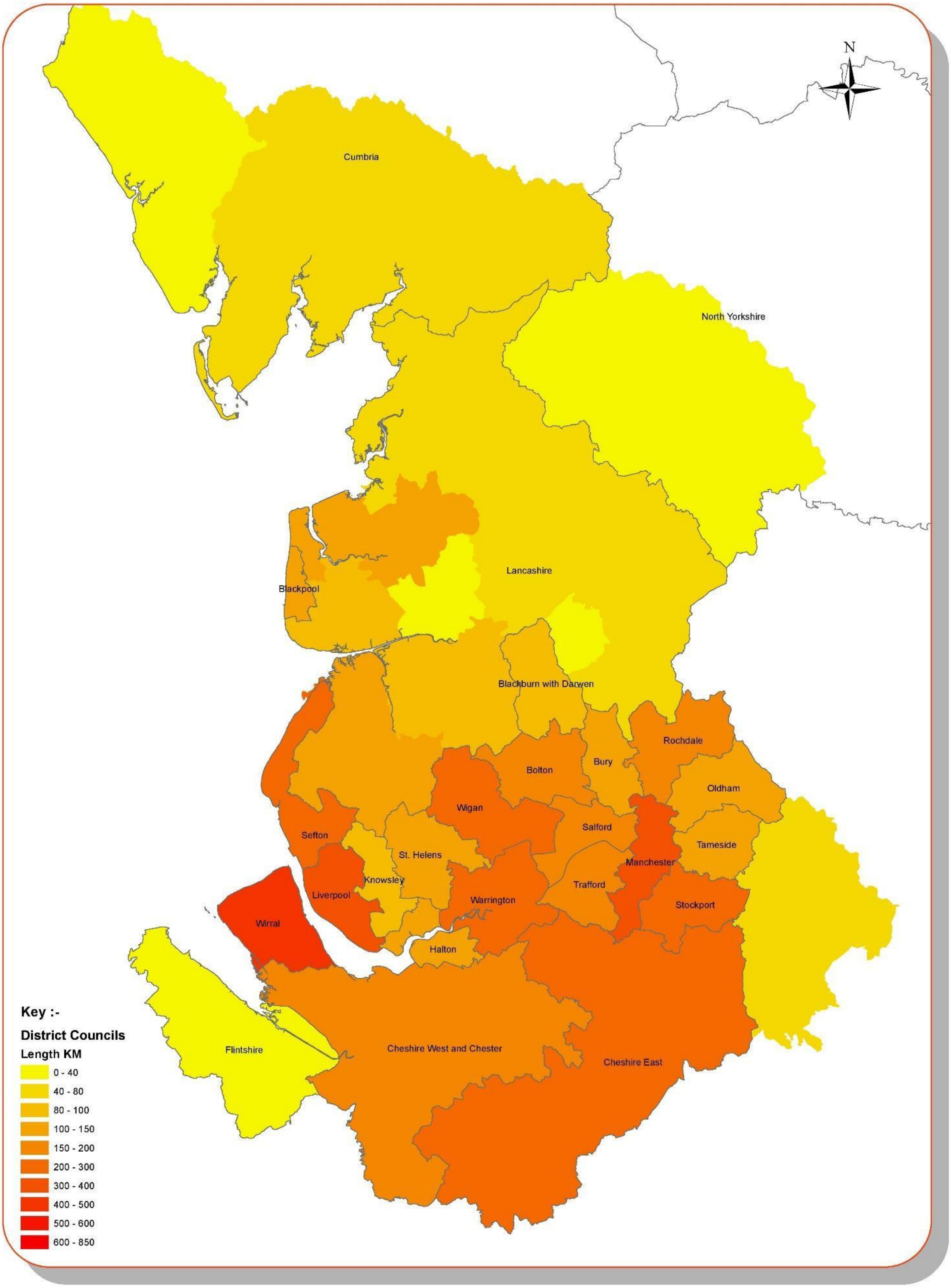

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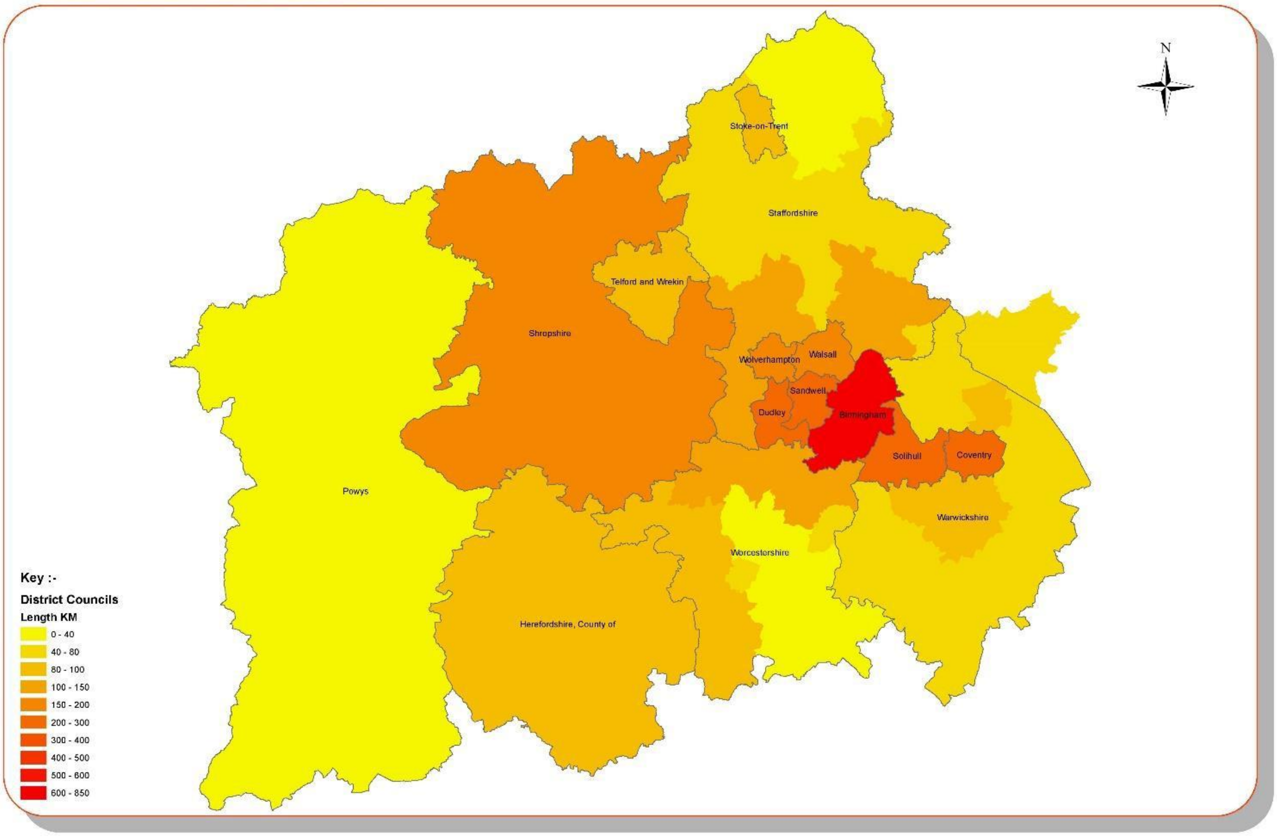
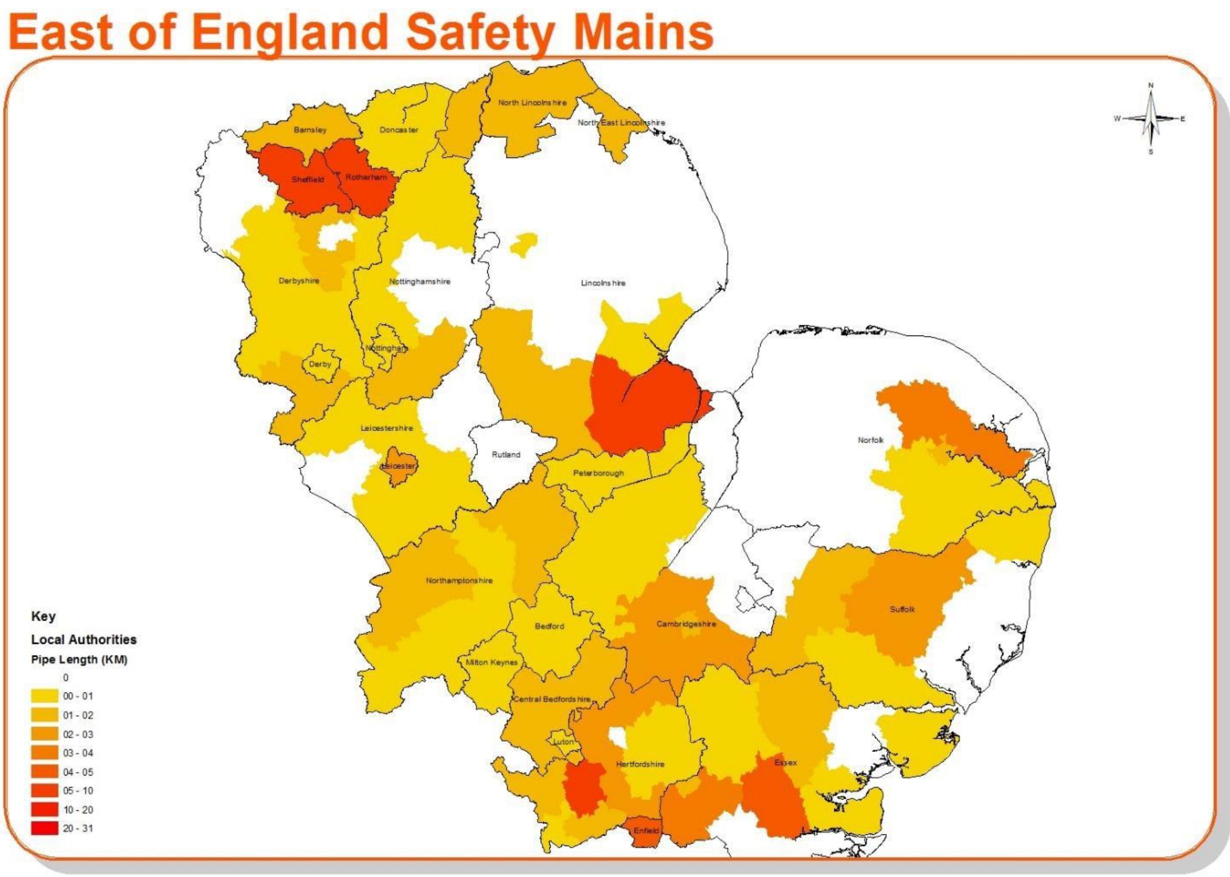
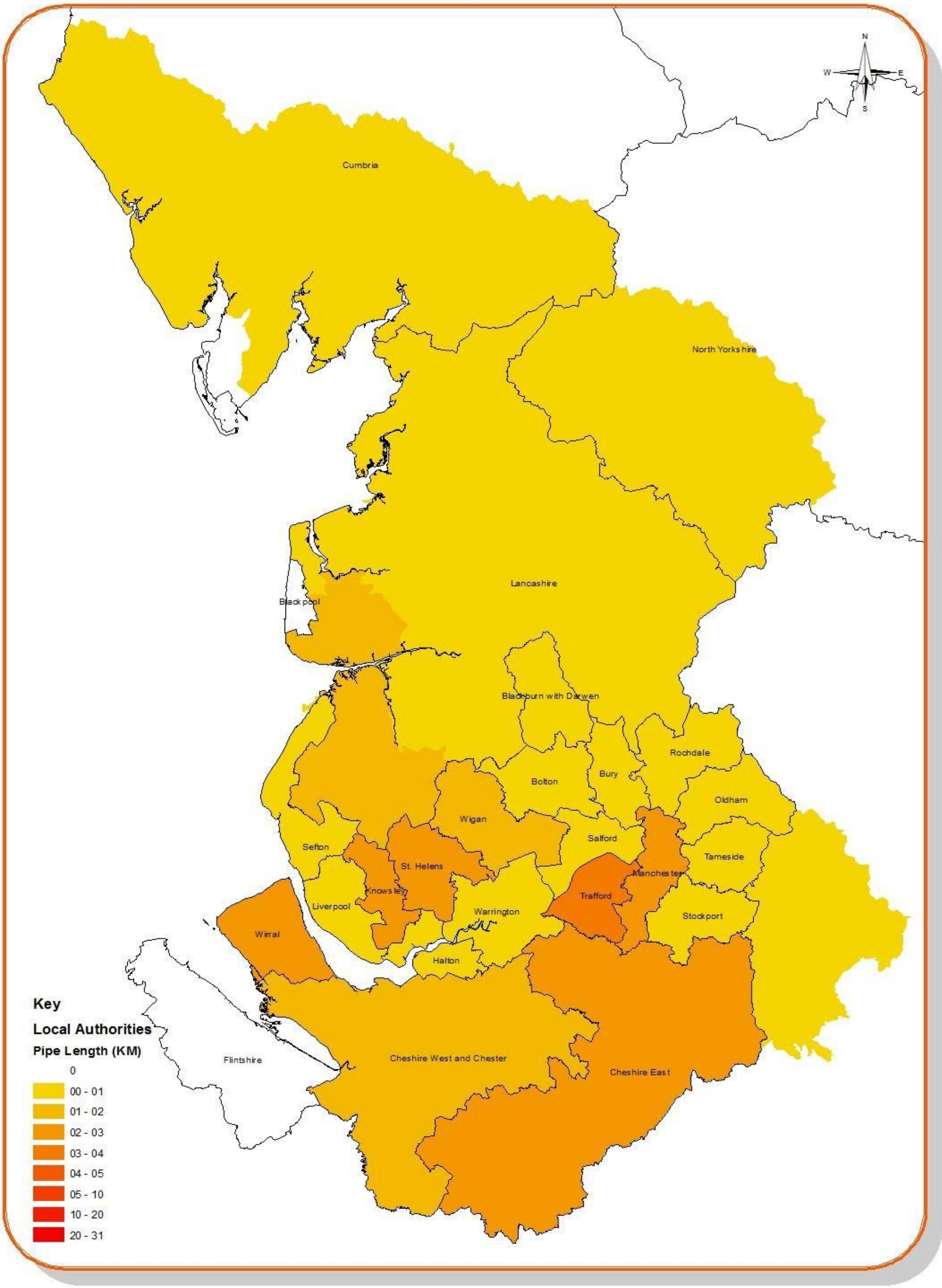


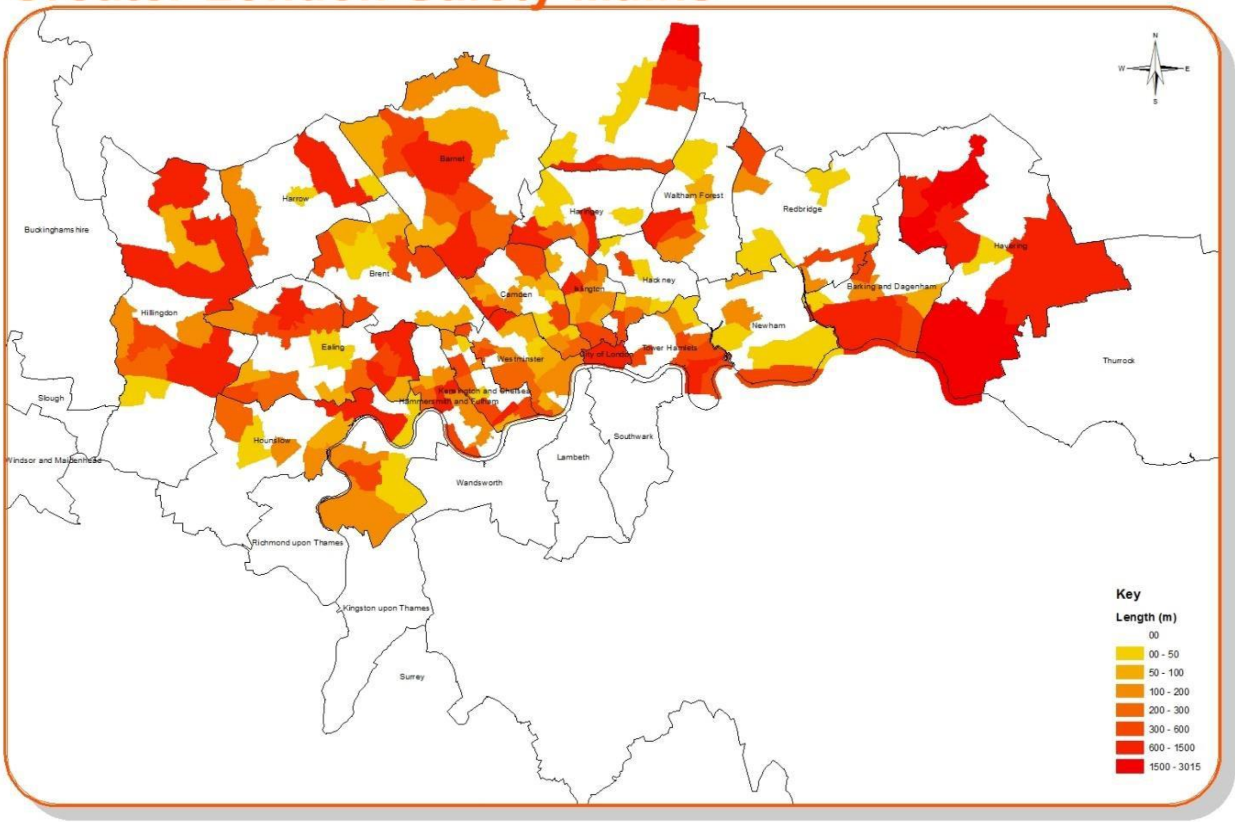
# Appendix 9. PAST Mains by Region



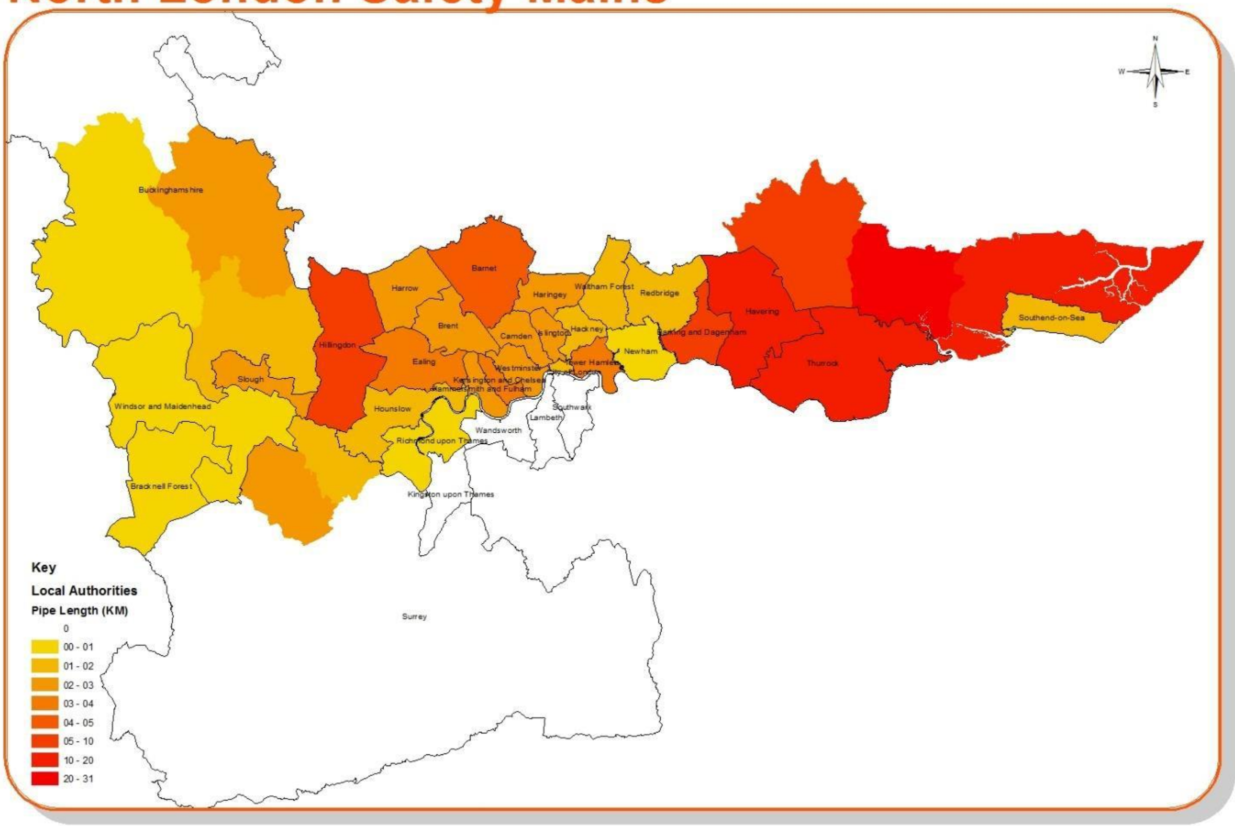
# North West Safety Mains



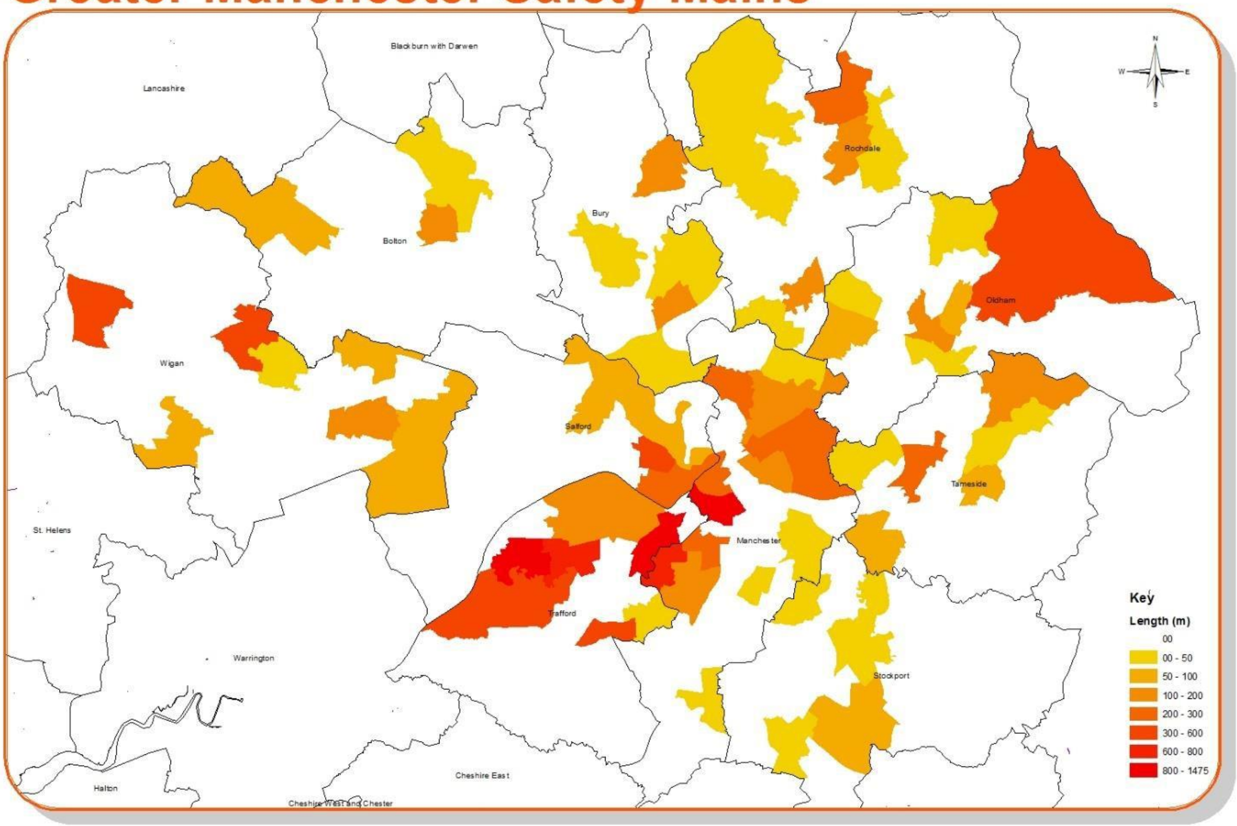
# Greater London Safety Mains



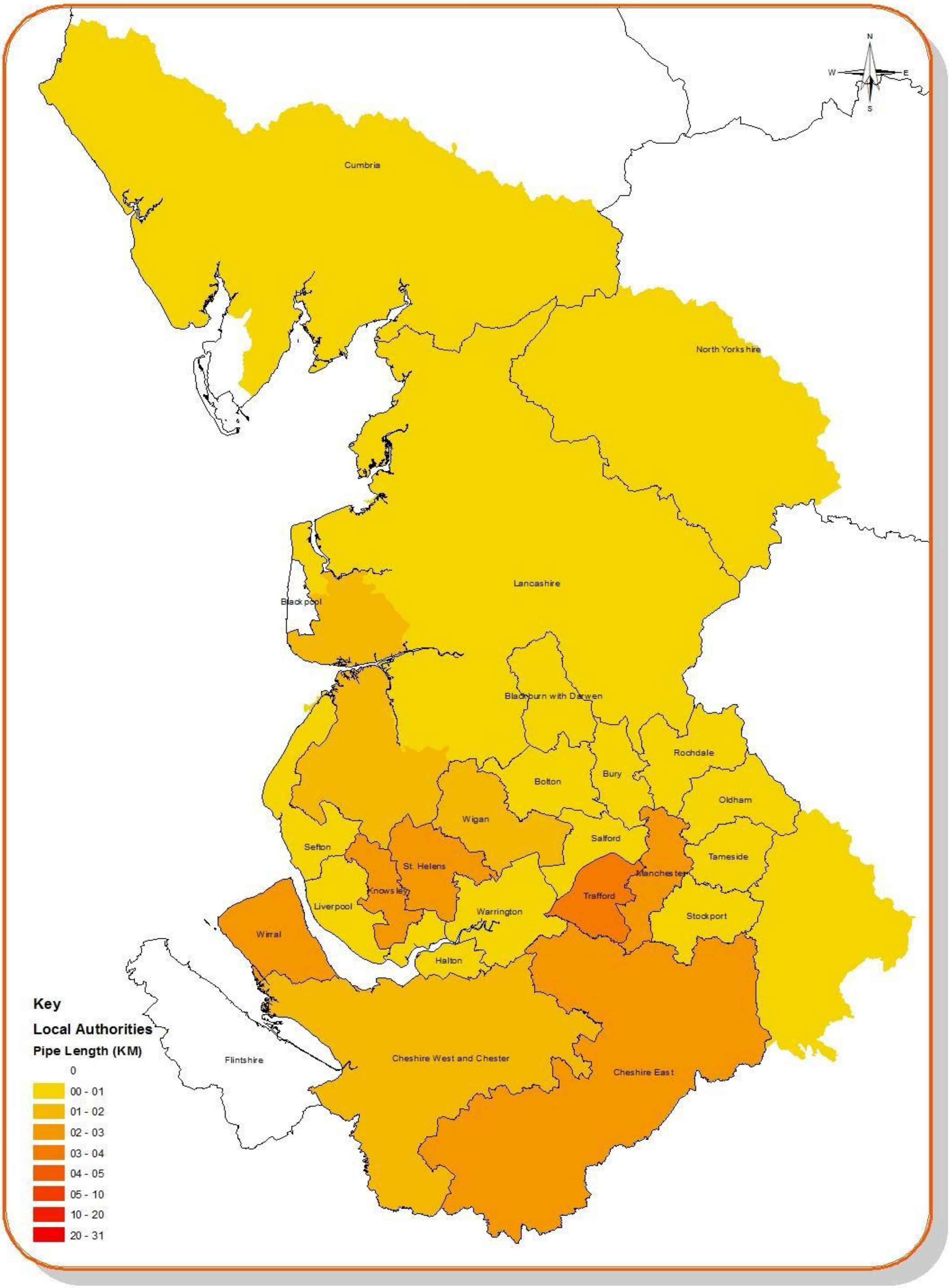
# North London Safety Mains



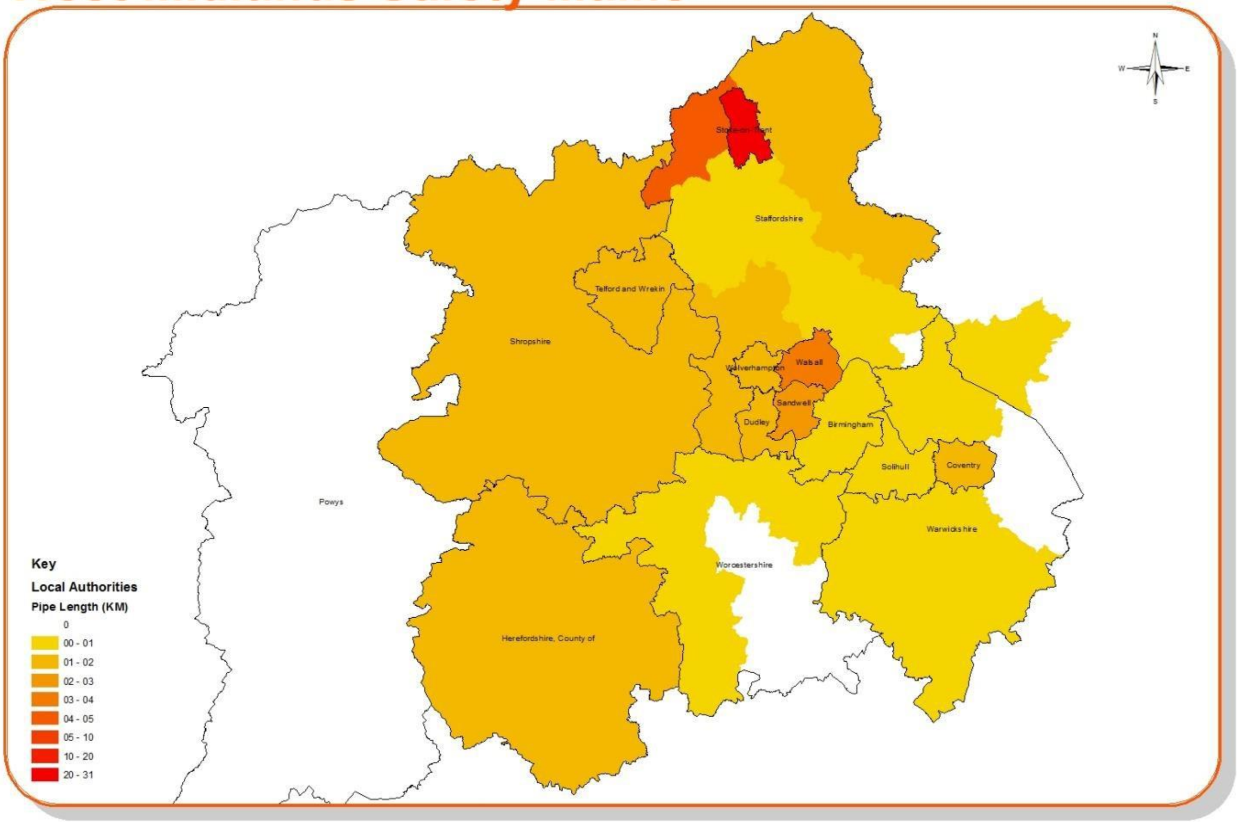
## Greater Manchester Safety Mains



# North West Safety Mains



# West Midlands Safety Mains



# Appendix 10. Risk Table for Mains and Associated Services

We have considered our ability to deliver the proposed workload. Given that our proposals are broadly similar on an annualised basis to those in RIIO-1, there are no expected constraints on delivery.

| Reference | Risk Description | Impact | Likelihood | Mitigation /Control |
|---|---|---|---|---|
| **09.03 - 001** | Supply & Demand deliverability risk of Resource availability within the Gas industry | Potential cost increases in labour / commodity markets as demand is greater than supply | Low | Intelligent procurement and market testing. Apprenticeship and Training programmes to fill skills gaps |
| **09.03 - 002** | Stretching efficiency targets may not be deliverable (unit costs increase) | Outturn costs are not met increasing overall programme costs. | Low | Established marketplace - ability to manage the known commodity market |
| **09.03 - 003** | Unforeseen outages and failures restrict access for planned work | Programme and delivery slippage due to delay of planned outages and or site access | Low | Proactive asset management with ongoing condition surveys and response plans to prevent failures |
| **09.03 - 004** | Unseasonal weather in 'shoulder months', Autumn and Spring reduce site access/outage windows | Increased demands affecting access to sites and planned outages delay and cost increases | Low | Controlled forecasting and maintenance of flexibility to react to unforeseen events. Detailed design solutions to minimise outages and reduce exposure. |
| **09.03 - 005** | Legislative change - There is a risk that legislative change will impact the delivery of our work. | Potential increase in the amount of consultation and information exchange required and require us to align our plans with the safety management processes operated by 3rd Party landowner / asset owners. The potential impact is more engagement and slower delivery | Med | We have established management teams to address these issues. We have also identified UMs for key areas. |

| Reference | Risk Description | Impact | Likelihood | Mitigation /Control |
|---|---|---|---|---|
| **09.02 - 007** | Safety mains - increase in MRPS risk scores | Increases the volume of safety work to meet requirements | Med | Contract flexibility to allow increases to be absorbed into current workscope. We have also identified UMs for key areas. |
| **9.02 – 008** | Our planning position is to assume **no seeds** for RIIO-2. This does not represent an agreed position with HSE. | We would lose opportunities to produce the best 'super string schemes' and, as such, average scheme length would decrease and costs would rise. | Med | We have a strong case to exclude seeds based on their effectiveness and have proactively engaged on the issue. |
| **9.02 – 009** | Our planning position is to assume **no stubs** require delivering in RIIO-2. This does not represent an agreed position with HSE. | There will need to be a change to the submitted plan as there will be a delivery and cost implication. | Med | Cross industry work has developed a clear position on stubs which is closely aligned to our approach in RIIO-1 |